

Forest Health Conditions in Wisconsin Annual Report 2002



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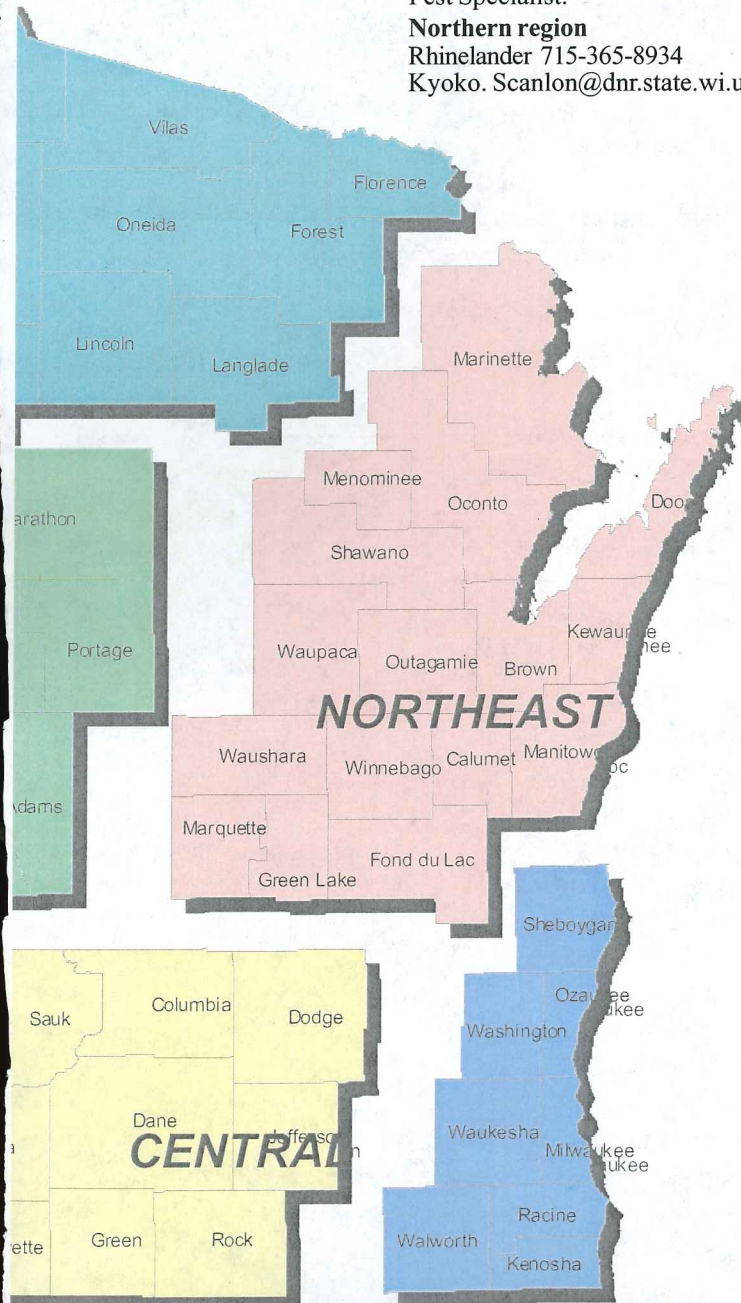
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Alerts

Tubakia leaf disease

widespread on bur and white oak



—A leaf disease caused by the fungus *Tubakia dryina* has recently been observed infecting bur and white oak throughout southern Wisconsin. Bur oaks are more commonly infected; white oaks are only occasionally infected. This disease has been observed on an annual basis for many decades but has increased in incidence and severity in the last 3 years. Infected bur oaks have been observed throughout southern Wisconsin and as far north as Portage County. Symptoms first appear in late July and consist of small, necrotic spots on leaves in the lower crown. Throughout August, spots expand, coalesce, and can eventually turn the whole leaf brown. Infected trees often have full crowns of shriveled, necrotic leaves in mid-late August. Bur oaks on a wide variety of

sites and of all ages have been infected. Trees that are already under stress from drought or compaction are showing signs of dieback. Samples collected from declining trees have revealed the presence of the two-lined chestnut borer. If these high levels of infection continue, further pressure by the two-lined chestnut borer is expected and may lead to increased mortality.



Red Pine Pocket Mortality

—A study was initiated in 2002 to investigate the distribution and causes of pocket mortality in red pine, a disease complex characterized by expanding centers of dead and dying trees. The fungus, *Leptographium spp.*, is brought in by several root and stem-feeding beetles. The incidence of red pine pocket mortality observed in this study was fairly high. The map on the right shows the location of surveyed stands and the number of pockets per stand. Over two-thirds (109) of 157 surveyed stands had at least 1 pocket.

The most important factor correlated with incidence was latitude, with southern plots showing a much higher number of pockets per stand as well as more trees per pocket. In addition, the close association of turpentine beetle and leptographium suggests that this beetle may play a pivotal role in the spread of disease. The next phase of the study, beginning in 2003, will involve comparisons of disease progression between stands where the pockets have been trenched and/or where beetles have been trapped out with non-treated stands.

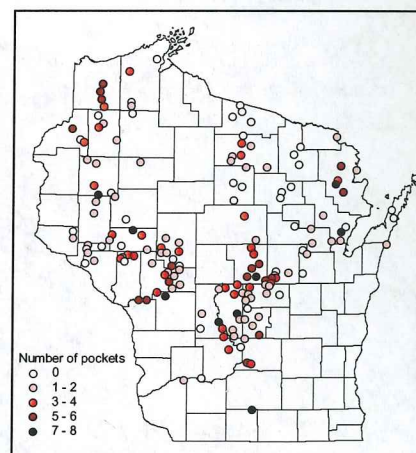
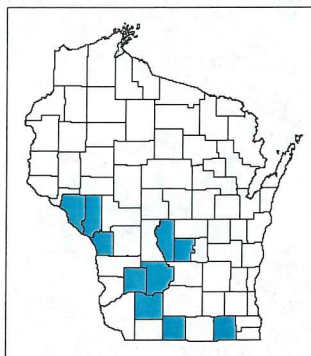


Figure 2. There were 344 pockets in the 157 sampled stands

Rhizosphaera Needlecast

—Thinning of spruce trees throughout the Northeast Region was attributed to *Rhizosphaera* needlecast (*Rhizosphaera kalkhoffii*). In the spring this disease infects newly emerging needles. Needles turn reddish-brown and drop prematurely in fall or early the following spring. Infection was uniform throughout the interior of the trees causing a general thinning appearance. Some smaller trees were experiencing mortality of the lower branches following this second year of heavy infection by *Rhizosphaera*.

Annosum Root Rot Update



H. annosum has been observed in 10 counties in Wisconsin.

—As part of a random survey of pine plantation for “Red Pine Pocket Mortality”, Annosum root rot (*Heterobasidion annosum*) was confirmed in six new counties in Wisconsin in 2002: Buffalo, Green, La Crosse, Marquette, Trempealeau, and Walworth. This brings the total to ten counties confirmed with this root rot disease (see map). In this random survey, 6 stands out of 157 stands (3.8%) surveyed were found infected with Annosum root rot. This survey offers baseline data regarding the frequency in which annosum infections are currently being detected.

A new publication comparing Annosum root rot with red pine pocket mortality can be observed at www.dnr.state.wi.us/org/land/forestry/fh/fhissues/annosum.htm. This publication outlines symptoms/signs and management recommendations. For a copy, email: jane.cummings-carlson@dnr.state.wi.us or call 608-275-3273.

Weir's cushion rust - *Chrysomyxa weirii*



—Weir's cushion rust, caused by the fungus *Chrysomyxa weirri* was observed on Colorado blue spruce landscape nursery stock in Dane and Sawyer counties. Symptoms in June include yellow spots and bands with erumpent telia on the previous year's needles. Infected needles are cast prematurely. This fungus requires no alternate host to complete its life cycle. Other hosts include *Picea englemanni*, *P. glauca*, *P. mariana* and *P. sitchensis*. This fungus has been reported in the western United States from the Black Hills of South Dakota to Washington state, and in the eastern United States from the southern Appalachian Mountains to Vermont. This is apparently the first report from the Great Lakes region.

The Resource

Proportion of Forest Land and Timberland

—The area of forestland in Wisconsin has been steadily increasing in recent decades and currently stands at 15.7

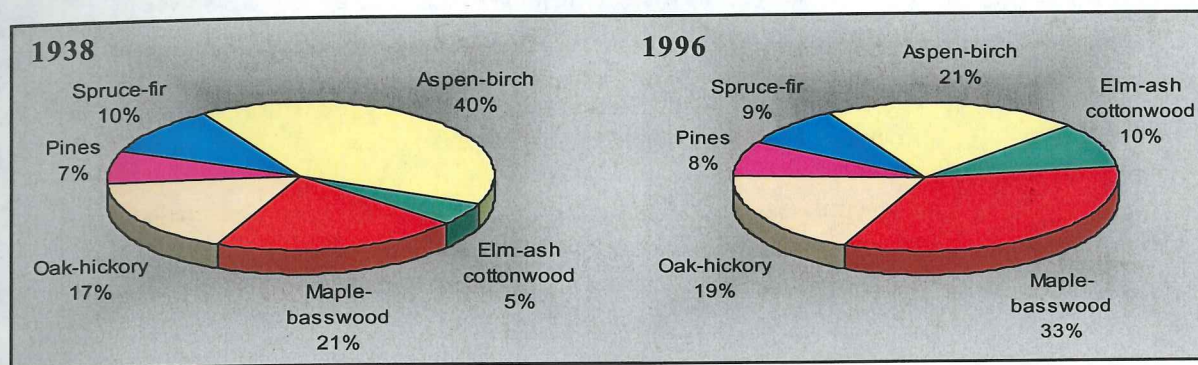


Figure 1. Percentage of timberland by forest type, 1938 and 1996. Data taken from 1938 and 1996 FIA surveys.

million acres, representing 46% of the total land area. This is an increase of almost 1 million acres since 1983. The state now has the most forest land it has ever had at any time since the first forest inventory in 1936. Wisconsin's forests are predominately hardwoods, with 84% of the total timberland area classified as hardwood forest types. The primary hardwood forest type in the state has changed from the 1930's when aspen-birch comprised 40% of timberland (Figure 1). As our forests have aged, these types which dominated on cut-over land have been replaced by later successional species such as maple-basswood, and oak-hickory which together account for 52% of timberland acreage.

Timberland is defined as forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development.

Ownership of Wisconsin's Timberland

—Individual private landowners are the largest group of timberland owners in Wisconsin, owning 57% of all timberland in 1996 (Figure 2). Counties and municipalities are the largest group of public owners, holding 15% of the total area of timberland in Wisconsin. The public owns a total of 30% of all timberland. The percentages of ownership have remained relatively constant since the forest inventory in 1956.

Growing-stock Volume of Wisconsin's Timberland

—Growing-stock volume on timberland in Wisconsin increased from 16.5 billion cubic feet in 1983 to 18.5 billion cubic feet in

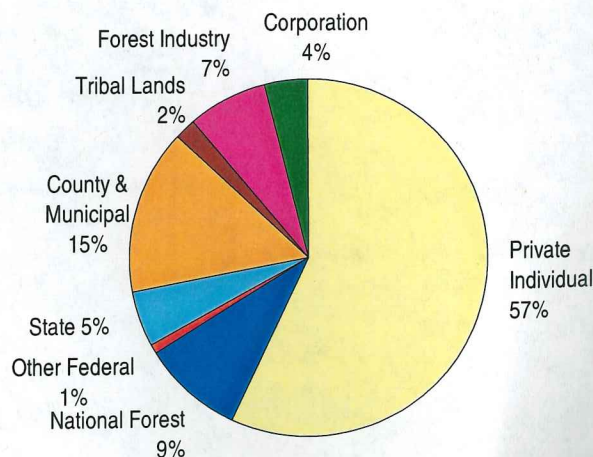


Figure 2. Forest ownership. (1996 FIA data)

1996, reflecting an increase in both area and stocking during the 13 years between inventories. In both 1983 and 1996, hardwoods accounted for $\frac{3}{4}$ of all growing-stock volume. Acreage in seedling-sapling stands had been decreasing and acreage in sawtimber stands had been increasing since 1938 reflecting the natural aging of forests since the turn of the century. However, since 1983, the area in young forests has increased and the acreage in sawtimber has decreased, especially in stands over 120 years of age (Figure 3).

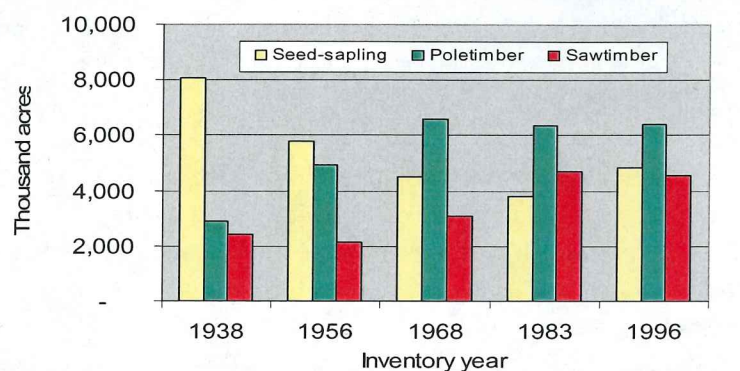


Figure 3. Acreage by size class on timberland in Wisconsin, 1938-1996. Data taken from 1996 FIA survey.

Most Common Species Groups of Wisconsin's Timberland

—The species groups with the most growing-stock were aspen, red oak, hard maple, and soft maple (Figure 4). The conifer species groups with the most growing-stock in 1996 were red pine and white pine.

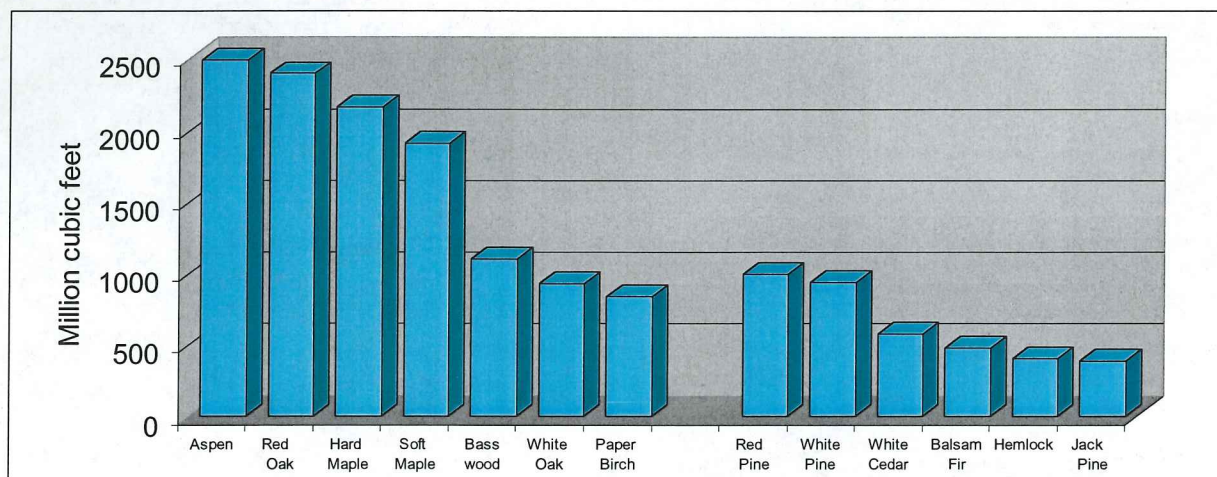


Figure 4. Most common hardwood and conifer species (in million cubic feet) on timberland in Wisconsin. Data taken from 1996 FIA survey.

Major Issues

Forest Tent Caterpillar

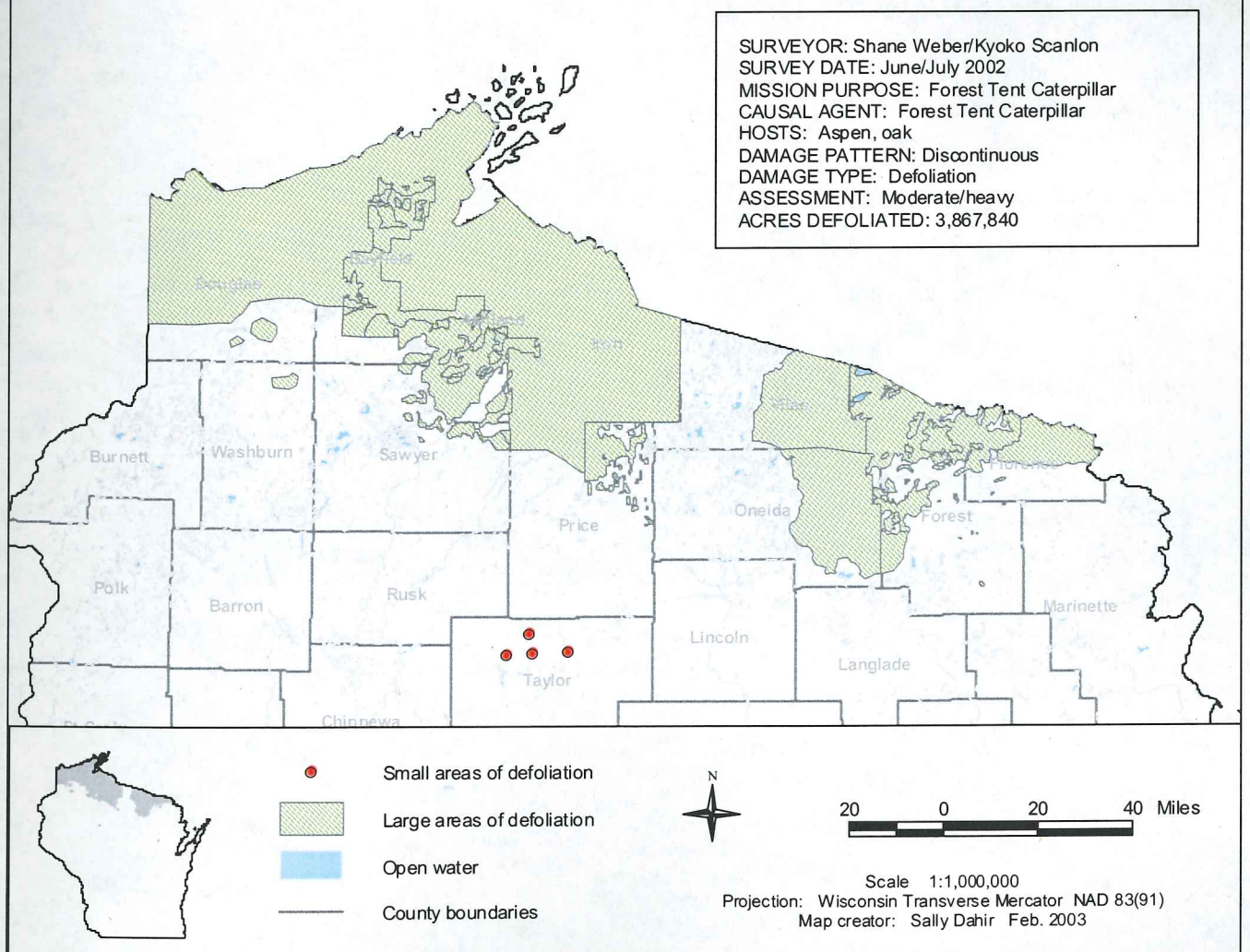


—2002 marked the fourth year of the forest tent caterpillar (*Malacosoma disstria*) outbreak in northern Wisconsin. Oak and aspen are the major hosts of this insect. This year, defoliation was much less severe in many of the areas where the infestation had been observed in previous years. However, damage was still seen in large parts of northern Wisconsin, and was severe in some newly infested areas.



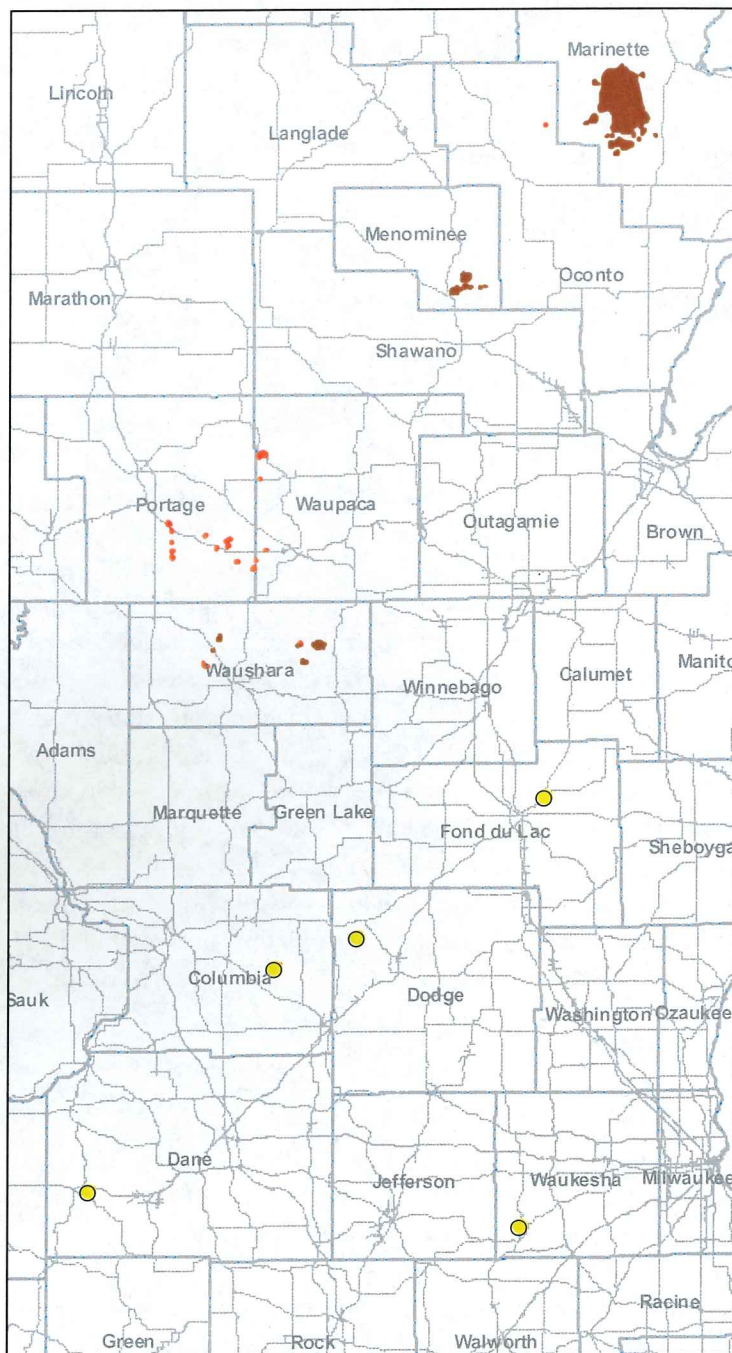
In June and early July, an enormous number of friendly flies (*Sarcophaga aldrichi*) were observed throughout northern Wisconsin. Friendly flies are a major natural enemy of forest tent caterpillars. Female adult flies lay maggots in the cocoons of the forest tent caterpillars, and maggots kill the pupae by feeding on them. Due to the overwhelming number of flies throughout northern Wisconsin, we expect that the current outbreak is winding down.

Approximate Area Affected by Forest Tent Caterpillar



Gypsy Moth

Bill McNee
Gypsy Moth Specialist Coordinator
Green Bay Wisconsin



—The year 2002 was busy for gypsy moth staff as the insect's populations continued to grow and spread across the state. Likewise, the Wisconsin Cooperative Gypsy Moth Program continued to expand rapidly. The number of counties participating in the Department of Natural Resources (DNR) suppression program grew from 2 in 2000-01 to 9 in 2001-02, and the total treatment area grew from 1,400 to 6,000 acres. Gypchek was used on 1,700 acres in Menominee and Oconto Counties, while all other spray blocks were treated with *Bt* (Foray 76B).

Overall, spraying in the past two years has been quite successful, and residents in treated areas have been pleased with the results. Spraying done through the DNR suppression program in 2002 cost \$23.85 per acre before cost sharing, and full cost sharing of 25-50% was returned to participating communities and landowners. Late in 2002 the minimum size of all spray blocks was reduced from 40 acres to 20 by an act of a state legislative committee, the Joint Committee for Review of Administrative Rules. For the 2002-03 program year DNR received applications to spray 29,000 acres in 17 counties as far west as the City of Stevens Point and as far north as the Town of Florence.

Patches of defoliation greater than 5 acres were seen in twelve counties (including new defoliation in central and southern Wisconsin), with the largest being 33,000 acres in central Marinette County. In 2002, statewide defoliation was approximately 35,000 acres, and there was no significant damage in urban areas. Defoliation occurred mainly in forest stands with a heavy oak



SURVEYOR: Bill McNee
Mark Guthmiller
DATE: July 2002
MISSION PURPOSE: Gypsy Moth
CAUSAL AGENT: Gypsy Moth
DAMAGE TYPE: Defoliation
AGENT(S): Gypsy moth
HOSTS: Aspen, Oak
ASSESSMENT: Moderate/Heavy
PATTERN: Contiguous
ACRES DAMAGED: 36,784



Highways

County boundary

Defoliation < 10 acres

Defoliated area

heavy

moderate-heavy

4 0 4 8 Miles

1:1,600,000

Wisconsin Transverse Mercator NAD83(91)

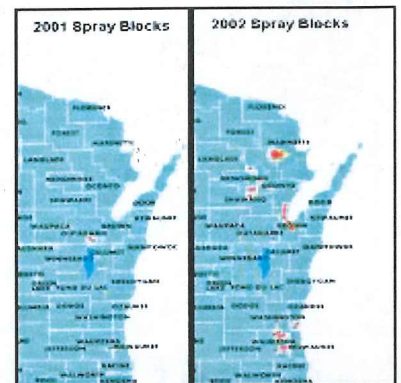
Map creator: Sally Dahir 2/2003



Heavy defoliation in Marinette County stripped individual jack pine and other conifers.

or aspen component, although in parts of Marinette County populations were high enough to heavily defoliate individual jack, white, and red pine, spruce, and even a few balsam fir (see figure on left). Defoliation in Marinette County and the rest of the state is expected to be greater in 2003, and will mainly occur in the areas surrounding those that experienced defoliation in 2002.

Approximately 330,000 acres were treated by the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) as part of the national slow-the-spread program. This included 310,000 acres treated with pheromone flakes and 20,000 acres treated with *Bt*. In 2001 approximately 175,000 acres were treated under this program. DATCP's trapping grid caught approximately 630,000 moths this year, compared to 380,000 in 2001 (a 67% increase). Nearly one-third of these moths were caught in Marinette and Oconto Counties, and at least one moth was trapped in 69 of 72 counties. Eight additional counties at the leading edge of the gypsy moth's Wisconsin distribution were placed under quarantine, for a total of 32.



Areas treated in 2001 and 2002 for the Slow-the-Spread program.



Gypsy moth defoliation along a road in northern Wisconsin.

Gypsy moth educational efforts also grew in 2002. During the summer gypsy moth staff received a near constant stream of phone calls from residents affected by the caterpillars, and provided advice to manage the caterpillars through individual actions or participation in the suppression program. Several new color brochures were created and distributed to the public, and a new DNR-UW Extension website was developed. The gypsy moth exhibit at the State Fair was very popular for the second year in a row, and several talks were given to landowner and civic groups. Numerous television and radio stories and newspaper articles appeared in the state media, primarily in Marinette, Peshtigo, Green Bay, Appleton, and Milwaukee. In

addition, Governor Scott McCallum declared October 6-12 to be 'Gypsy Moth Awareness Week' in Wisconsin.

Oak Wilt

Ceratocystis fagacearum

—Efforts continue to focus on public information of prevention techniques and surveys of the northern leading edge of this disease in Wisconsin. A new pocket was located in northern Florence County, T40N, R9E, Sec. 19. This indicates that oak wilt is not confined to the Spread Eagle Chain area in Florence County.



Known distribution of oak wilt in Wisconsin 2002.

Barron County was added to the county distribution when oak wilt was confirmed on a wooded residential lot on the west shore of Prairie Lake, T33N R11W Sec.13 DSE1/4. Trees in a mixed stand of northern pin oak and pine were infected.

Oak wilt was also confirmed on the Nine Mile section of the Marathon County Forest following a selective harvest in July and August. Oak wilt had not been previously present in the area, thus infection likely occurred as a result of wounding during the harvest. Late-summer infection is uncommon in Wisconsin yet not impossible. A management plan to minimize the impact of oak wilt on the Nine Mile property has been developed.

Minor Issues

Eastern Larch Beetle



—Eastern larch beetle (*Dendroctonus simplex*) caused localized mortality in tamarack stands in the Northeast Region, including Oneida and Vilas counties. This native bark beetle can attack relatively healthy trees as well as stressed tamarack. Many of the stands affected don't seem to be under an inordinate amount of stress and all show good annual ring growth rates. Heavy resin flow is common on attacked trees. Areas of mortality vary from a small pocket of trees to more than 40 acres.

Two-lined Chestnut Borer

—Mortality of mature oak by a native beetle, the two-lined chestnut borer (*Agrilus bilineatus*), was observed throughout northern Wisconsin again this summer (especially in Vilas, Oneida, and Lincoln counties in the northeast and in Douglas, Sawyer, Bayfield and northern Washburn counties in the northwest). Normally a weak secondary invader of oaks injured by wind, ice or lightning, the two-lined chestnut borer (TLCB) attacked trees this year that had been defoliated by the forest tent caterpillar. Multiple years of defoliation, coupled with dry weather and sandy soils can make defoliated trees much more vulnerable to attack.



Adult two-lined chestnut borer

This flat-headed beetle mines the cambium of stressed oaks, eventually killing them. Infested trees often show browning and dieback of leaves starting in the upper crown and progressing downward. Due to a dramatic decrease in the population of forest tent caterpillar this year (caused by friendly fly predation), mortality due to TLCB is expected to decrease as well. Luckily, oak wilt has not yet affected the northern region and most oaks should recover next year.

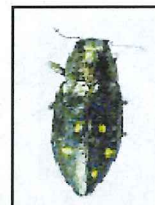
Tar Spot



—Weather conditions once again favored the development of the fungus that causes Tar Spot (*Rhytisma spp.*) and locally heavy infections were reported throughout the Northeast Region. Native maple species as well as many cultivars of maples were infected with this leaf disease. Tar spot is a cosmetic disease that first infects the leaves in the spring with the characteristic black spots showing up in late summer. This disease usually does not affect the productivity of the tree but a few areas had such heavy infections that leaves were dropping early.

Hemlock borer

—Mortality of mature hemlock trees was observed in eastern Oneida County. Infestations by the hemlock borer (*Melanophila fulvoguttata*) were found on dying and dead hemlock trees. The insect is considered a secondary pest, and usually attacks weakened, dying, or recently killed trees. Infested trees show thinning and fading on their upper crown and dieback progresses downward. A windstorm in excess of 50 miles per hour hit the area on August 14, 2000. Blown down trees were left on site in the areas where hemlock mortality was observed. It is suspected that the windstorm, and dry and hot July in 2001 helped develop the populations of this insect.



Sphaeropsis

—*Sphaeropsis sapinea* is the cause of a fungal disease of many conifers. This fungus can affect trees as a shoot blight, collar rot, or branch canker disease. In 2002, mature red pine in the southern unit of the Kettle Moraine State Forest were affected by *Sphaeropsis sapinea* acting as a branch canker disease. Areas with heavy branch and some tree mortality were investigated. Heavy resin pitch was observed on affected branches. Spores of *Sphaeropsis sapinea* were isolated from these cankers to confirm the disease.



Drought has been shown to increase a tree's susceptibility to this disease. Hail is also often an initiator of branch cankers caused by *Sphaeropsis*. The lack of moisture the last couple of years along with possible hail wounding likely caused the increased prevalence of this disease in the southern unit of the Kettle Moraine State Forest.

The wood wasp, *Urocerus cressoni*, was also observed at the base of recently killed trees. This species is common throughout the eastern U.S. and Canada on *Abies*, *Picea*, and *Pinus* species.

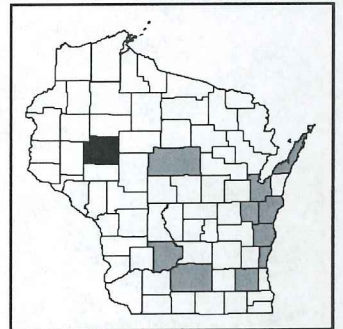
Ash Yellows

—Ash yellows, caused by a phytoplasma, was confirmed in white ash on the Chippewa County forest. This disease



Brooms or epicormic branches are indicative of ash yellows.

is typically more common in urban settings or in woodlots bordering agricultural fields. Confirmation of infection was based on the presence of brooms along the lower portion of the infected trees' stems. Ash yellows is now confirmed to be present in 11 counties. Affected stands typically have a few (less than 12) infected trees scattered throughout the stand. Symptoms include upward cupping of the leaves, dieback and the presence of cracks and brooms on the lower stem. Mortality of infected trees can occur over time. Ash yellows is likely trans-



mitted by sap sucking insects.

Other Pests Reported in 2001

Pest	Host	Damage	Location
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Ash

Anthracnose (<i>Gnomoniella fraxini</i>)	Green ash	Browning and curling of infected leaves. Premature leaf drop	Scattered throughout the West central and Northeast regions
Ash plant bug (<i>Tropidosteptes amoenus</i>)	Green ash	leaf stippling	Brown Co., Outagamie Co.
	White ash	Moderate to heavy stippling with some necrosis and leaf drop	Washburn and Sawyer counties
Ash Yellows	Ash	Declining and dead trees. Declining trees had thin crowns, cupped-chlorotic foliage. Witches brooms were present on the dead trees.	Chippewa County Forest
		tree decline	Door Co., Brown Co.
		branch dieback with brooms present	Jefferson County
Forest tent caterpillar (<i>Malacosoma disstria</i>)	Ash	Areas of heavy to moderate defoliation, Population down from 2001	Northwest region
		defoliation	Brown Co., Outagamie Co.
Mountain ash sawfly (<i>Pristiphora geniculata</i>)	Rowan tree	Scattered light to moderate defoliation	Douglas, Bayfield counties

Aspen

Aspen blotch miner (<i>Phyllonorycter</i> spp.)	Aspen	Light to moderate defoliation of open-grown aspen, Down from 2001	North central region
Forest tent caterpillar (<i>Malacosoma disstria</i>)	Aspen	defoliation	Marinette Co., Oconto Co.
Venturia leaf blight (<i>Venturia tremulae</i>)	quaking aspen	twig tip curling/death	Oconto Co., Marinette Co

Balsam Fir

Balsam twig aphid (<i>Mindarus abietinus</i> Koch)	Balsam Fir	Widespread needle curling & tip distortion	across Northwest region
Rhizosphaera needlecast (<i>Rhizosphaera pini</i>)	Balsam Fir	needlecast	Door County

Basswood

Introduced basswood thrips (<i>Thrips calcaratus</i>)	Basswood	Light to moderate defoliation in one small pocket (<1,000 acres)	Bayfield County
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Birch

Bronze birch borer (<i>Agrilus anxius</i>)	White birch	Top dieback and tree mortality	Lincoln, Oneida, and Vilas Counties
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Cherry

Eastern tent caterpillar (<i>Malacosoma americanum</i>)	Wild Cherry	Defoliation of the trees.	Scattered throughout the WCR Burnett, Polk, & Washburn counties
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Pest	Host	Damage	Location
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Christmas Trees

Cyclaneusma needlecast (<i>Cyclaneusma minus</i>)		Needle loss, making the trees not as full as they should be.	Adams County
Pine root collar weevil (<i>Hyllobius radicus</i>)	Scotch Pine	General tree decline leading to some scattered mortality.	Adams County
Rhizosphaera needlecast (<i>Rhizosphaera spp.</i>)	Colorado Blue Spruce	Needle discoloration and needle loss.	Chippewa County
Sphaeropsis Shoot Blight (<i>Sphaeropsis sapinea</i>)	Colorado Blue Spruce	Dead shoots (new growth).	Chippewa and Eau Claire counties.
		Death to new shoots and associated browning on the tree.	Adams County
Spider mites (<i>Oligonychus ununguis</i>)	Colorado Blue Spruce	Needle discoloration.	Chippewa County

Crab Apple

Eastern tent caterpillar (<i>Malacosoma americanum</i>)	Flowering crab	Defoliation of the trees.	Scattered throughout the WCR.
Fire blight (<i>Erwinia amylovora</i>)	Flowering crab	Dieback	Scattered throughout Milwaukee metro area

Elm

Dutch elm disease (<i>Ophiostoma ulmi</i>)	Elm	Tree death	Northwest & Northeast Regions Throughout Washington and Waukesha counties
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Hemlock

Hemlock borer (<i>Melanophila fulvoguttata</i>)	Eastern hemlock	Mortality	Oneida County
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Hickory

Painted Hickory Borer (<i>Scolytus quadrispinosus</i>)	Hickory sp.	firewood infested with this round headed borer	Dane County
Phylloxera (<i>Phylloxera spp</i>)	Hickory sp.	galls on leaf stem	Dane County

Larch

Larch needlecast (<i>Mycosphaerella laricina</i>)	European larch	Average 60% defoliation in ~40% of plantations	Lorraine township, Polk County
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Maple

Fall webworm (<i>Hyphantria cunea</i>)	Many hardwoods	Light defoliation, much lower populations than 2001	Northwest Region
Gall mites (<i>Eriophyid mites</i>)	Red maple Sugar maple	Bladder, erenium, and spindle galls on leaves	Throughout the Headwaters Basin

Pest	Host	Damage	Location
Maple petiole borer (<i>Caulocampus acericaulis</i>)	Sugar Maple	Premature leaf drop	Shawano, Brown, Oneida & Vilas counties Washburn & Sawyer counties
Maple webworm (<i>Tetralopha asperatella</i>)	Sugar maple	Webbing/leaf feeding, Populations down	Florence, Oneida, Vilas Counties Northwest Region
Tar Spot (<i>Rhytisma spp</i>)	Silver maple	Leaf damage	Brown Co., Shawano Co., Kewaunee Co., Manitowoc Co., Oconto Co., Calumet Co. West Central Region
Woolly Alder Aphid (<i>Prociphilus tessellatus</i>)	Silver Maple	White woolly insects flying around on leaves. Honeydew and sooty mold forming on various surfaces.	Scattered in West Central Region.

Oak

Actinopelte Leaf Spot (<i>Actinopelte dryina</i>)	White, Red Oak	Leaf damage	Walworth, Waukesha Counties Green and Waukesha Counties
Anthracnose	White oak	Moderate to heavy infections	Cumberland area NWR
	Red oak	Brown blotches on leaf, premature leaf drop	Northeast Region
	Red Oak Group	Browning and curling of infected leave. Premature leaf drop.	Scattered throughout the WCR.
Botryosphaeria canker (<i>Botryosphaeria dothidea</i>)	Oak	Seedling mortality and girdling of seedling mainstems	Shawano Co.
Cynipid Wasps (<i>Cynipidae spp</i>)	White Oak	Galls on twigs	Dane and Rock counties
Forest tent caterpillar (<i>Malacosoma disstrata</i>)	Red oak	Moderate to heavy defoliation	Throughout the Northern Region
Kermes scale (<i>Kermes spp.</i>)	N. pin oak	Heavy infestations produced common branch flagging	Northwest sand flats
	Red oak	Flagging and twig dieback	Oneida and Vilas Counties
Gypsy Moth (<i>Lymantria dispar</i>)	Oak and other hardwoods	Moderate to heavy defoliation	Eastern Wisconsin including Columbia, Dane, Dodge, Green, Jefferson, Portage, Waupaca counties
Two-lined chestnut borer (<i>Agrilus bilineatus</i>)	Oak	Scattered moderate mortality following defoliation by forest tent caterpillar	Washburn, Sawyer, Douglas , Bayfield countie: Brown, Marinette, Shawano, Menominee, Waupaca counties
		Tree mortality	Florence, Lincoln, Oneida, Vilas counties Dane County
Oak tatters	Red, White Oak	Moderate to heavy leaf deformities	Dane County
Oak wilt (<i>Ceratocystis fagacearum</i>)	Red oak	Oak mortality	Scattered throughout West central region
			Marinette Co., Oconto Co., Menominee Co., Shawano Co. Florence County
		Barron County newly positive , Grantsburg County	Burnett County
Voies	Oak, hardwoods and conifers	Tree mortality due to stem girdling in young plantation	Dodge County
Walking stick (<i>Diapheromera femorata</i>)	pin oak	Defoliation	Marinette Co.

Pest	Host	Damage	Location
Pine			
Aphids (<i>Cinara spp</i>)	White pine	Rare due to ladybug predation	NWR
Annosum root rot (<i>Heterobasidium annosum</i>)	Red pine, (Also Jack Pine in La Crosse County)	Pockets of tree mortality	Buffalo, Green, LaCrosse, Marquette, Trempealeau, and Wolworth Counties
	Jack, Red, and White Pines	Large trees as well as understory saplings and seedlings were killed. The popcorn stage and conks were found on the dead trees.	The LaCrosse Hoeth County Forest, and LaCrosse County. Additional counties in the WCR where Annosum has been found include: Adams, Buffalo, and Trempealeau.
Armilaria root rot (<i>Armillaria mellea</i>)	Red pine	Tree mortality	LaCrosse County
	Jack, Red, Scotch, and White Pines	Trees are declining, leading to some mortality.	Scattered throughout the WCR.
	Red pine	~5% mortality in plantations, high mortality in old balsam fir	Northwest Region
Bark beetles (<i>Pityogenes hopkinsi</i>)	Jack, Red, Scotch, and White Pines	Tree mortality.	Scattered throughout the WCR. Northwest region
Eastern pine shoot borer (<i>Eucosma gloriola</i>)	Jack Pine	Damage was noticed on Jack Pine saplings. Branches turned brown and wilted.	Monroe County Northwest sand flats
Gall Rust (<i>Cronartium spp</i>) (<i>Endocronartium spp.</i>)	Jack and Scotch pines	Decline in tree vigor, leading to branch and/or tree mortality.	Scattered throughout the WCR.
Introduced pine sawfly (<i>Diprion similis</i>)	White pine	Defoliating needles	Grant County
Ips bark beetles (<i>Ips spp</i>)		Dying trees, scattered and locally heavy damage	Shawano Co., Brown Co., Oconto Co., Marinette Co.,
	Jack, Red, Scotch White Pines	Tree mortality.	Scattered throughout the WCR & NWR Localized pockets throughout the Headwaters Basin
Jack pine budworm (<i>Choristoneura pinus</i>)	Jack Pine	Light defoliation to the crown of the Jack Pine.	Adams and Juneau counties.
Pine Bark Adelgid (<i>Pineus strobi</i>)	White Pine	The insects were feeding on understory White Pine. No visible damage was noticed.	LaCrosse County
Pine Chafer Beetle (<i>Anomala obliqua</i>)	Various conifers	The insects were flying in moderate numbers, no visible damage was noticed.	Chippewa and Eau Claire counties.
Pine false webworm (<i>Acantholyda erythrocephala</i>)	White pine	defoliation of pole and sawtimber sized white pine	Waushara Co.
Pine needle rust (<i>Choleosporium spp</i>)	Red pine	Acial blisters on needles	Oneida County
Pine Needle Scale (<i>Chionaspis pinifoliae</i>)	White Pine	The insects were feeding on understory White Pine needles. No visible damage was noticed.	Scattered throughout the WCR.
Pine root collar weevil (<i>Hylobius radialis</i>)	Scotch Pine	An abandoned Scotch Pine Christmas tree plantation was heavily infested with the Pine Root Collar Weevil. Just about every tree examined had the weevil. There was widespread mortality and decline throughout the plantation.	Jackson County

Pest	Host	Damage	Location
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Pine (continued)

Pine Spittlebug (<i>Aphrophora cribrata</i>)	White pine	Present at reduced population	NWR
Red pine needle midge (<i>Contarina baeri</i>)	Red pine	Light to moderate defoliation in Wascott township	Northern Washburn & Douglas counties
Red pine pocket decline	Red pine	Pocket mortality	LaCrosse, Lafayette, Sauk Counties Shawano, Marinette, Waupaca counties Throughout the WCR.
Red turpentine beetle (<i>Dendroctonus valens</i>)	Red and Scotch Pine	Trees have declining vigor, and can help lead to tree mortality.	Scattered throughout the WCR. Shawano, Brown, Oconto, Marinette counties
		Tree mortality associated with deep planting and turpentine beetles	Wood County
		Basal attacks fairly common in first years after 2nd & 3rd thinings	Northern Washburn, Douglas counties
Redheaded Pine Sawfly (<i>Neodiprion lecontei</i>)	Red pine	Heavy defoliation	Oneida and Vilas Counties
Sphaeropsis collar rot and shoot blight (<i>Sphaeropsis sapinea</i>)	Red Pine	Stem and branch cankers causing branch and tree mortality	Adams, Marathon and Walworth counties
	Jack, Red, and Scotch Pines	Collar rot caused tree mortality to red & jack pine seedlings. Shoot blight caused shoot and/or branch mortality.	Scattered throughout the WCR and state
White Grubs	Red Pine	Feeding on the roots of newly planted seedlings, causing heavy mortality.	Jackson County
White Pine Blister Rust (<i>Cronartium ribicola</i>)	White Pine	Trunk and branch cankers. Some tree and branch mortality.	Scattered throughout the WCR.
White Pine Weevil (<i>Pissodes strobi</i>)	Jack, Scotch, and White Pines	Terminal leader killed on open grown saplings. Open grown Jack Pine was preferred over open grown White Pine in the same area.	Scattered throughout the WCR.
	White pine	Terminal leader death	Brown, Manitowoc, Door, Oconto counties
Zimmerman Pine Moth (<i>Dioryctria zimmermani</i>)	Scotch pine	Tree mortality and stem breakage due to Zimmerman moth and sapsucker damage	Columbia County Waupaca, Manitowoc counties
	ornamental pines	Pitch flows	Scattered throughout Milwaukee metro area

Spruce

Eastern spruce gall adelgid (<i>Aldelges abietis</i>)	White spruce	Pineapple-shaped galls at the bases of new shoots	Lincoln, Oneida, and Vilas Counties Door, Brown, Outagamie, Winnebago counties
Rhizosphaera needlecast (<i>Rhizosphaera kalkhoffii</i>)	Blue Spruce	Needle discoloration and drop	Scattered throughout Milwaukee metro area Oneida and Vilas Counties
Sirococcus shoot blight (<i>Sirococcus spp</i>)	White Spruce	Curled shoots and needle loss	Vilas County
Spruce Gall Midge (<i>Cecidomyiidae spp</i>)	White spruce	Galls on new shoots	Menominee County
		Swollen, curled shoots and needle loss	Vilas County
Spruce needle rust (<i>Chrysomyxa spp.</i>)	Colorado Blue & White Spruce	Needle loss	Oneida and Vilas Counties
White pine weevil (<i>Pissodes strobi</i>)	white spruce & blue spruce	Terminal leader death	Shawano

Pest	Host	Damage	Location
Tamarack			
Larch beetle (<i>Dendroctonus simplex</i>)	Tamarack	Pockets of heavy mortality in pole and small sawlog stands of mature tamarack	Washburn, Sawyer, Price counties
		Top dieback and tree mortality	Oneida and Vilas Counties Winnebago, Fond du Lac, Brown, Door Waupaca, and Marquette counties
Larch bark beetle (<i>Dendroctonus simplex</i>)	Tamarack	Declining and dead trees. Part of the problem could be due to a beaver dam that raised the water table in the area.	Marathon County

Willow

Imported willow leaf beetles (<i>Plagiodera versicolora</i>)	Willow	Light to severe feeding damage	Oneida County
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Abiotic Factors

Hail Damage	Jack, red, and white pines, and oaks.	Northern area is stabilizing. Much of the worst damage was salvaged.	Douglas County
		Southern area continued to decline in pine with continued advance of oak wilt	Polk County

Special Surveys

Jack Pine Budworm Survey Procedures and Results: 2002

Shane Weber, DNR Forest Entomologist
Dept of Natural Resources
Spooner, Wisconsin

Early larval survey

This survey is done on a yearly basis and is a key indicator of the presence of destructive budworm populations. Thirty shoots and staminate flowers (15 of each) that can be reached from the ground are checked for larvae. Since staminate flowers are often scarce, a majority of shots are usually used. A count of 10 or more infested shoots and flowers is considered sufficient to cause moderate to severe defoliation.

Early Larval Populations

County	No. Plots	No. Infested Shoots	Infested Shoots/ Plots	No. High Plots	% High Plots
Polk	15	9	0.60	0	0
Burnett	24	15	0.63	0	0
Washburn	21	11	0.52	0	0
Douglas	54	19	0.35	0	0
Bayfield	32	5	0.16	0	0
District	146	59	0.40	0	0

Early Larval Population Trends

County	No. Infested Shoots/Plot						% High Plots				
	1998	1999	2000	2001	2002	%Change 2001-2002	1998	1999	2000	2001	2002
Polk	0.67	2.60	2.47	6.00	0.60	-90	0	13.3	6.7	26.7	0
Burnett	1.46	1.29	1.08	0.83	0.63	-24	4.2	4.2	0	0	0
Washburn	7.14	6.57	0.24	0.52	0.52	0	28.6	28.6	0	0	0
Douglas	13.03	4.17	0.36	0.28	0.35	+25	81.5	9.3	0	0	0
Bayfield	7.47	1.63	0.09	0.13	0.16	+23	25.0	0	0	0	0
District	7.79	3.32	0.62	0.97	0.40	-59	40.4	9.6	0.7	2.8	0

Jack Pine Budworm Pupal Survey

This survey is also conducted annually and gives a good indication of the kinds and numbers of pupal parasites in the population as well as next year's population of jack pine budworm. It is done in July when most insects are in the pupal stage. Some adults may already have emerged, but empty pupal cases are collected and counted as emerged moths. At each stop, pupae are collected on a time basis. If five pupae are not found in five minutes, the collection is terminated. If five pupae are found in 5 minutes or less, the collection is continued until 25 pupae are found or until 15 minutes have elapsed. The time required to find 25 pupae is then recorded. Adults, parasites and non-emergence are recorded for each pupae.

Pupal Survey

County	Total Pupae	Total Minutes	Pupae/Min	Moths		Parasites		Not Emerged	
				No.	%	No.	%	No.	%
Polk	24	85	0.28	15	62.5	8	33.3	1	4.2
Burnett	37	125	0.30	33	89.2	4	10.8	0	0
Washburn	12	105	0.11	9	75.0	2	16.7	1	8.3
Douglas	62	270	0.23	48	77.4	12	19.4	2	3.2
Bayfield	13	160	0.08	12	92.3	0	0	1	7.7
District	148	745	0.20	117	79.1	26	17.6	5	3.3

Pupal Population Trends

County	1999 Pupae/min	2000 Pupae/min	2001 Pupae/min	2002 Pupae/min	%Change 2001-2002
Polk	0.63	0.74	0.57	0.28	-51
Burnett	0.44	0.21	0.31	0.30	-3
Washburn	0.66	0.07	0.13	0.11	-15
Douglas	0.13	0.05	0.13	0.23	+77
Bayfield	0.03	0.01	0.03	0.08	+167
District	0.32	0.15	0.19	0.20	+5

Jack Pine Budworm Parasite and Predator Complex

This survey involves a careful examination of all the budworm pupae collected which do not produce moths. Adult specimens are compared to a reference collection. Any unknown adults are sent to the University of Wisconsin for identification. Pupal cases from which nothing emerges are dissected to ascertain the cause of failure.

Parasite/ Predators	Polk	Burnett	Washburn	Douglas	Bayfield	Total	% of Parasitized	% of Total
Itoplectes	2	1	0	6	0	9	34.6	6.1
Scambus	0	0	0	1	0	1	3.8	0.7
Phaogenes	0	0	0	2	0	2	7.7	1.4
Pteromalids	0	2	0	0	0	2	7.7	1.4
Tachinids	2	0	0	2	0	4	15.4	2.7
Predators	4	1	2	1	0	8	30.8	5.4
Total	8	4	2	12	0	26		

Sally Dahir
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Fitchburg, WI

Background and Objectives

Red pine pocket mortality was first reported in Wisconsin in 1975. Initially a relatively obscure disease, in the past five years we have seen a dramatic increase in the number of pockets reported in certain parts of the state. Red pine pocket mortality is actually a disease complex involving several species of root and lower stem-feeding insects along with their fungal symbionts. They initiate a sequence of events which create circumscribed areas or "pockets" of progressive mortality of one to several trees (Figure 1). Once introduced, fungal hyphae spread through the extensively grafted root system of red pine stands continually stressing new trees. These otherwise healthy pines then become attractive to beetle attack, creating an expanding border of dead trees. Unless root grafts are severed, harvesting symptomatic trees will not halt the spread of the fungus to healthy trees.



Figure 1. A typical pocket has trees in several stages of mortality indicating the progressive nature of the disease.

Work by Klepzig, Raffa and Erbilgin from the University of Wisconsin was critical in more closely defining the role of various species of insects and fungi as well as more accurately delineating the sequence of events. The main fungal species involved in initial pocket establishment are *Leptographium terebrantis*, and *L. procerum*, which are vectored into the area by root weevils, such as *Hylobius pales*, *H. radialis*, and *Pachylobius picivorus* and lower stem-feeding bark beetles, in particular *Dendroctonus valens* (red turpentine beetle) and *Hylastes porculus*. Once initially stressed, these trees become very susceptible to attack by bark beetles, specifically *Ips pini* and its fungal associate, *Ophiostoma ips*. These latter are thought to be responsible for ultimate tree mortality.

Although we had a fairly good idea of the major agents of disease as well as the sequence of events leading to tree mortality, there are several questions which remain unanswered. For instance, what is the distribution of the disease in the state? What stresses lead to pocket initiation and why do we find pockets in one part of a stand and not another? And finally, are there any site, stand, or management factors which are correlated with disease incidence or severity?

In 2001, members of the Dept of Natural Resources Silvicultural Committee in conjunction with the staff of Forest Health Protection initiated a multi-year study of red pine pocket decline. The objectives were 1) to determine geographic differences in disease incidence and severity, 2) to investigate site or stand characteristics or past management practices which might be correlated with disease incidence, and 3) to develop, from this analysis, silvicultural guidelines which would help prevent pocket formation and/or limit expansion of pockets already established.

Methods

The study was divided into 2 stages. The first involved an extensive survey of randomly selected 30-40 year old red pine stands to determine geographic distribution of the disease and to identify site or stand characteristics correlated with incidence. The second stage would involve an intensive study of selected stands to further delineate the role of

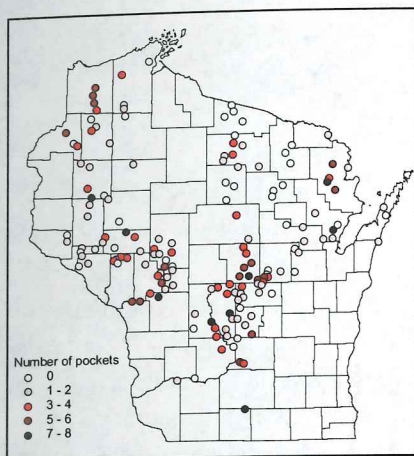


Figure 2. There were 344 pockets in the 157 sampled stands

trees, old snags, new snags, recently dead, dying, fading (tufted foliage and thin crown) and healthy trees with evidence of turpentine beetle (such as pitch tubes or granules, Figure 3). Where there was evidence of turpentine beetle and/or staining, a wood sample was taken to determine if *Leptographium* spp. was present. In recently cut stands, where all dead trees had been removed, stumps showing turpentine beetle damage, were sampled. Samples were not taken where the wood was too rotted.

Results

The map on this page (Figure 2) shows the location of surveyed stands and the number of pockets per stand. Of 157 sampled plantations, 109 or 69% had pockets. A total of 344 pockets were observed averaging slightly over 3 pockets per stand. As expected, however, there was a wide variation in number of pockets per stand. Most stands with pockets had only a few but a substantial number had several (Figure 4). For instance, 55 or half of these stands had 1-2 pockets but 25 or almost $\frac{1}{4}$ had 5 or more pockets or a minimum of 1 pocket for every 2 acres. In addition, most pockets were very small but a few were quite large. Over $\frac{3}{4}$ of all pockets, north and south, had 5 symptomatic trees or fewer but about 4% had over 26 trees. As a total percentage of trees, however, this still amounts to about 0.3% of all red pine in these stands.

There were a few important differences due to geographic location, specifically between northern and southern Wisconsin. (The province divisions, 212 and 222, which are divided along the tension zone were used to distinguish northern from southern plots.) For instance, pockets were less numerous and smaller on average in northern Wisconsin than in the southern part of the state (Figure 4). The number of pockets per stand, average pocket size (number of symptomatic trees) and maximum pocket size were significantly higher ($p=0.059$, $p=0.001$, and $p=0.029$, respectively) in southern Wisconsin. Also, the number of pockets increased with decreasing tree density ($p=0.028$). Of eight stands which had never been thinned, only 1 had any pockets.

factors identified in stage one.

Forty-two counties and 157 stands were surveyed (Figure 2). In each stand, the basal area, mean diameter (at breast height) and habitat type were recorded. Ten acres per stand were surveyed for pockets. A pocket was defined as either a single recently dead tree (dominant crown class) showing evidence of turpentine beetle or a group of 2 or more trees in progressive stages of mortality with at least one having died fairly recently. These criteria were established in order to both capture newly formed pockets and to rule out one-time events such as lightning strikes or severe drought, which would not create pockets of spreading disease.

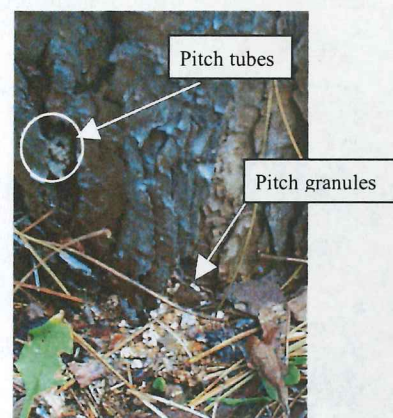


Figure 3. Pitch tubes or granules were indicative of turpentine beetle damage.

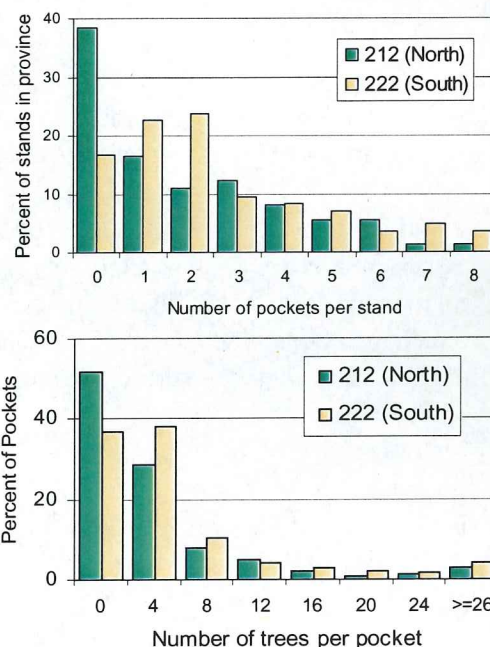


Figure 4. There were more pockets per stand and more tree per pocket in southern Wisconsin (province 222) than in the north (province 212).

The relationship of site quality to disease incidence or severity was not clear-cut. In the north (Figure 5), there was a correlation between the number of pockets and habitat type with very dry sites having significantly more pockets than all other types ($p=0.018$) and with more mesic habitat types showing a lower incidence of pockets (not significant). In the southern part of the state however, there was no correlation between habitat type and the number or size of pockets. In fact, more mesic sites had more pockets per stand on average than did the driest habitat types. The amount of variance between stands for all

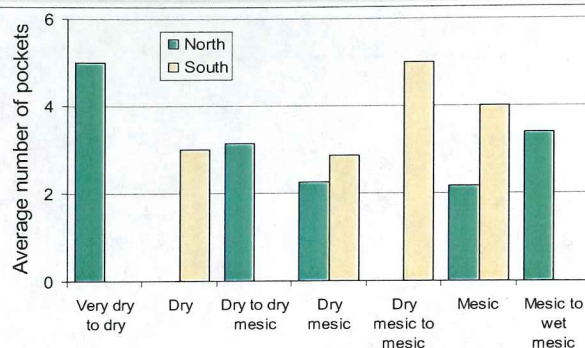


Figure 5. There were significantly more pockets on very dry sites in northern Wisconsin but no difference in pocket number or size between habitat types in the south. Parameters were very high, especially in the south

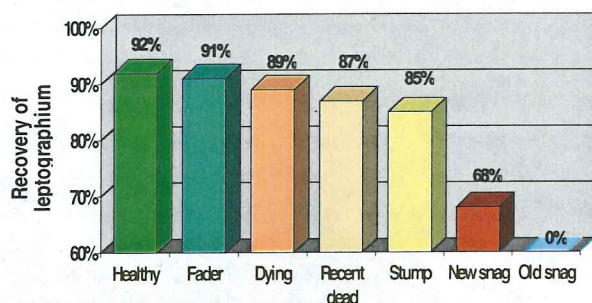


Figure 6. Recovery of Leptographium fungi was highest in the least decomposed wood.

tissue.

Discussion

The incidence of red pine pocket mortality observed in this study was higher than expected. Over two-thirds (109) of 157 surveyed stands had at least 1 pocket. However, the number of pockets per stand was small in most cases and most pockets had few symptomatic trees, over one-third having fewer than 6. On the other hand, there were several stands with a large number of pockets, over 1 pocket for every 2 acres surveyed and where pockets were fairly large, averaging between 1 and 2 percent of all red pine in these stands. This wide variation suggests either that pocket decline is worse on some sites and self-limiting on others or that it is just beginning to show up in many red pine stands throughout the state and that these small pockets may expand rapidly in the near future.

With respect to geographic distribution, there does seem to be an important difference in disease incidence and severity between northern and southern Wisconsin. The number of pockets, as well as the average and maximum size of pockets per stand is lower in northern Wisconsin. Pocket size also seems to be more dependent on site quality in the north. For instance, mesic sites have significantly lower levels of disease than very dry sites in northern Wisconsin whereas, in the south, there's no difference between dry and mesic habitat types.

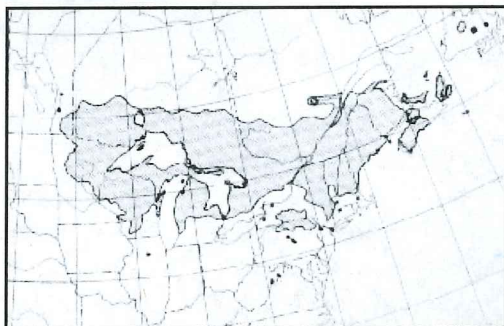


Figure 6. Red pine is on the lower edge of its range in southern Wisconsin.

There are several possible reasons for this difference. In southern Wisconsin, red pine is on the lower edge of its range (Burns and Honkala, 1990) and may be more susceptible to temperature variations. There is evidence that temperatures, specifically average winter minimum temperatures have risen substantially in Wisconsin in the

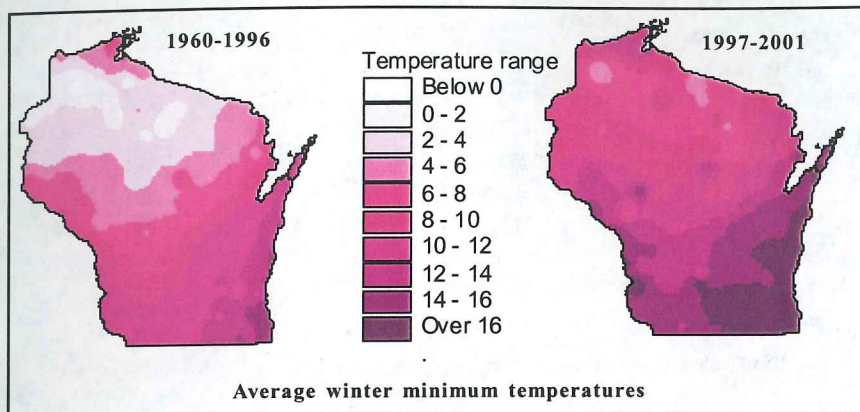


Figure 7. Winter minimum temperatures have increased 4-6 degrees Fahrenheit in the last 5 years (1997-2001) compared to the previous 40 years (Wisconsin Climatology Office).

Site quality in general did not seem to be strongly correlated with disease incidence. Habitat type was only significant in northern Wisconsin where an increase in the incidence of disease was observed on very dry sites. Other site factors, however, may affect where pockets are initiated. For instance, it was frequently observed that new pockets were located adjacent to forest roads, low-lying areas or wetlands. Along roads this may be due to root and stem damage caused by logging machinery and in wet areas (Figure 8), damage to red pine root systems caused by water-logged soils. For older pockets, it was usually too difficult to determine pocket origin.

Figure 8. Pockets are frequently initiated in low areas where moisture may cause stress on trees.



Figure 9. *Dendroctonus valens* (red turpentine beetle)

A very important finding of this survey was the co-occurrence of red turpentine beetle (*Dendroctonus valens*, Figure 9) and *Leptographium spp.* (Figure 10) in the vast majority of pockets. For instance, *Leptographium* was recovered in wood samples from 95% of stands with pockets, 91% of all pockets and most importantly, 96% of pockets with visual evidence of *D. valens*.

There are two species of *Leptographium* which are associated with red pine pocket decline, *L. terebrantis* and *L. procerum* (Klepzig et al, 1991). The former is much more commonly associated with red turpentine beetle (*D. valens*). For instance, Klepzig recovered *L. terebrantis* from 73% of *D. valens* samples and *L. procerum* from only 7%. Although we did not identify species in this study, this evidence would implicate primarily *L. terebrantis* due to the recovery of samples from areas on the bole showing signs of turpentine beetle attack.

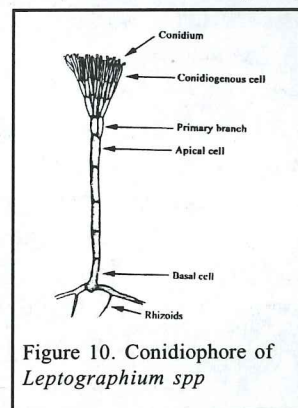


Figure 10. Conidiophore of *Leptographium spp*

These two fungal species, *L. terebrantis* and *L. procerum*, may serve very different functions in pocket development. *L. terebrantis*, though incapable of directly causing tree mortality, has been shown to be a much more virulent fungus and capable of causing severe water stress in otherwise healthy trees. In a study by Owen (et al 1987), *L. terebrantis* killed 70% of white pine seedlings whereas *L. procerum* did not produce any mortality. The authors noted that *L. terebrantis*, when vectored by *D. valens*, could cause significant damage to a tree's vascular system even if the beetle failed to produce a brood and the tree survived. Wingfield (1986) observed that *L. terebrantis* was capable of producing lesions which were much larger than those of *L. procerum*, and, in a recently published compendium on *Leptographium* (2001), Jacobs and Wingfield state that *L. terebrantis* is "highly pathogenic" and "the primary cause of root disease in red pine".

In addition to being more virulent, *L. terebrantis* is vectored primarily by *D. valens* and *Hylastes porculus*, lower stem-feeding bark beetles which may play a more aggressive role in pockets than the root-feeding insects (*Hylobius radialis*, *H. pales*, and *Pachylobius picivorus*) which serve primarily as vectors of *L. procerum*. In Klepzig's 1991 study, *D. valens* and *Hylastes porculus* were found to be significantly more abundant in pockets than the root insects (28.03 and 7.82 insects trapped per period, respectively). In addition, these insects were relatively more abundant beyond the pocket margin whereas the root-feeding insects were more numerous within the pocket.

These facts suggest that *D. valens* and *L. terebrantis* may play an aggressive role in pocket expansion and possibly in pocket initiation. A primary feeding site for these beetles is freshly cut stumps as well as healthy trees nearby. We noticed in this survey that pockets were almost nonexistent in unthinned stands, i.e. where no stumps were present. We also observed very high numbers of *D. valens* in very recently thinned stands surveyed during the period of beetle flight in late spring. In addition, the number of pockets decreased significantly as tree density increased. This may be due to the cooler and darker microclimate in dense stands, which would be much less conducive to beetle activity.

These observations point to the possible role of thinning and specifically the time of year in which a stand is thinned in pocket formation. In a study of Douglas fir stands 15 years post-thinning, Harrington (et al, 1983) reported that the number of trees killed by *Leptographium wagnereii* increased as the residual stand density decreased, ranging from 19% to 35% mortality of crop trees. Interestingly, there was no mortality in the 6 unthinned stands in their study. Time of year of thinning may also be correlated with pocket initiation in that stumps which are allowed to dry out for long periods prior to spring beetle flight may be less attractive as brood sites. In a study of Douglas fir stumps by Witcosky et al (1986), the attack intensity of *Hylastes nigrinus* was only 2.9 in stands thinned during June or July, compared to 14.6 in stands thinned in September through January. The authors concluded that these stumps probably had more time to dry out especially during the hot summer months.

There were a few difficulties encountered in the survey which should be mentioned. For instance, the fact that dead and dying trees had been removed at various intervals prior to the survey made it much more difficult to accurately determine the number of pockets and trees per pocket in many of these stands. In addition, our criteria for defining pockets did not include an examination of tree roots in order to ascertain that *Leptographium* was actually spreading in the root systems, indicating the progressive nature of the disease. We did not dig roots because of the tremendous amount of time and labor and the desire to survey as many stands as possible in a short time. We felt that both the criteria used to identify pockets as areas of progressive mortality and the recovery of *Leptographium* from the stem of a symptomatic tree in the pocket, were sufficient to adequately meet the definition as outlined earlier.

Areas of Future Investigation

Several questions were raised by the results of the first stage of this study that we would like to address in the intensive phase. These include: 1) does the rate of pocket expansion vary on different sites or in different parts of the state 2) does the time of year when a stand is thinned affect vector populations and the probability of pocket initiation, and 3) can we more accurately assess the species of *Leptographium* which play a role in pocket initiation and/or expansion with the use of DNA analysis? We will continue research on these questions in the subsequent 2-5 years. To answer the first question, we will select red pine stands which will be thinned at various times of the year. Traps in these stands will be monitored in the spring for turpentine beetle numbers and the stands will be surveyed annually for newly formed pockets. To address the second question, we will select several stands from the initial survey which have multiple small (1-4 tree) pockets. These will be located using global positioning equipment and symptomatic trees will be marked. These stands will then be revisited annually to determine the rate of pocket expansion.

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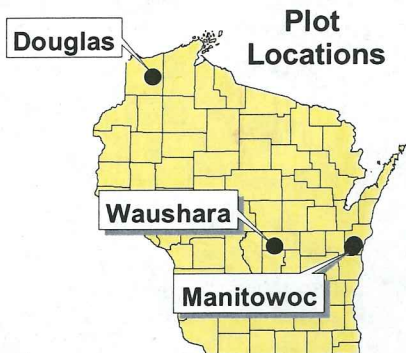
Wind and Hail Storm Damage

Final Assessment 2002

Sally Dahir
Forest Health Technician
DNR Fitchburg WI

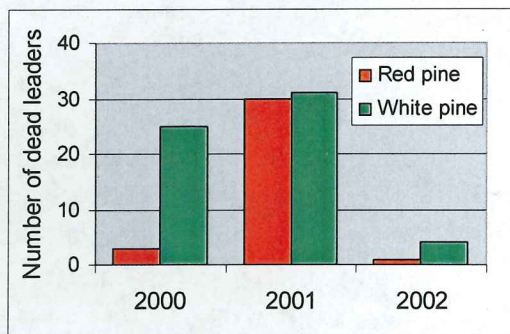
Introduction

—This summer marked the third year in a follow-up survey of tree damage caused by 2 major storms in central and northwest Wisconsin. The first, in May 2000, affected mainly Waushara, Marquette, and Manitowoc counties and the second, in August, hit Douglas and Juneau counties. Both storms involved very high wind speeds and large hail. At that time, questions were raised as to the future health of affected trees. One of our major concerns was whether stands would recover to a merchantable condition or whether immediate harvest would prevent the proliferation of insect and disease problems. In naturally regenerated stands, we wanted to see both the effect of heavy overstory damage on regeneration as well as the impact of harvesting technique on the rates of sprout and seedling establishment.

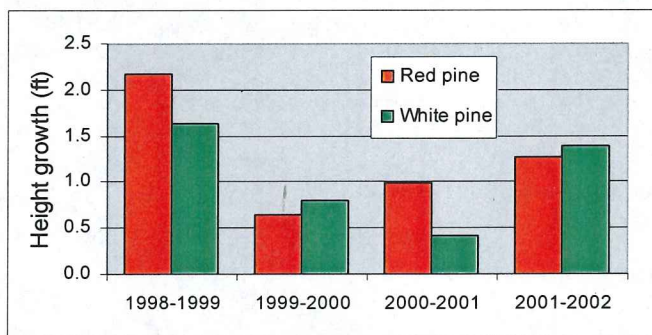


In 2000, study sites were set up in Manitowoc, Waushara, and Douglas counties (see map) to establish baseline measures of overstory conditions immediately after the storms. In 2001 and 2002, these plots were resurveyed to observe both overstory condition, specifically crown dieback and transparency, and regeneration success.

In the Waushara County red and white pine stand, tree health improved dramatically. Lateral branches had taken over in 92% of trees with dead leaders in 2001 (see figure below). Height growth had improved significantly as



The number of dead leaders in both red and white pine has decreased dramatically from 2001 to 2002.



Height growth has improved by 66% overall and 230% in white pine.

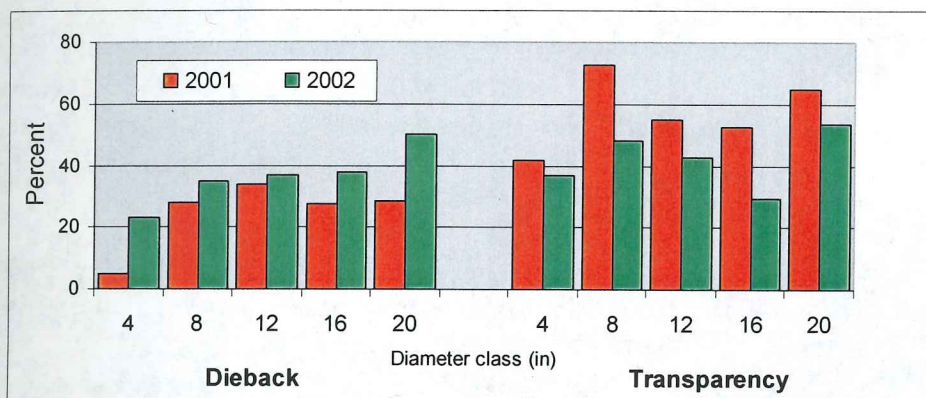


A comparison of the condition of pines immediately after the 2000 hail storm (left), one year later (middle), and in the summer of 2002.

well, about 66% higher overall with an increase of over 230% for white pine. Dieback, which had averaged about 40% in 2000 and 25% in 2001, was down to about 15% this year. This stand seems to have recovered quite well. The photos on the previous page were taken in successive years. Notice the lack of brown branches or dead leaders in the picture on the far right, taken in 2002. In this case, harvest does not seem to have been necessary as the stand is recovering well. A severe drought or other stress in years subsequent to the storm might have caused much higher mortality.

In Manitowoc County, the lowland silver maple – ash stand which had been clearcut after the storm, continued to show more than adequate regeneration of both silver maple and ash, whereas the selectively cut lowland stand continued to show almost total lack of silver maple reproduction (*see Forest Health Conditions in Wisconsin Annual Report 2001*). This may be due to the fact that the surviving silver maple was using all of its stored energy to produce new foliage instead of sprouts. Since the canopy trees were too badly damaged to survive, if these trees had been cut, all of this stored energy might have been available for production of sprouts.

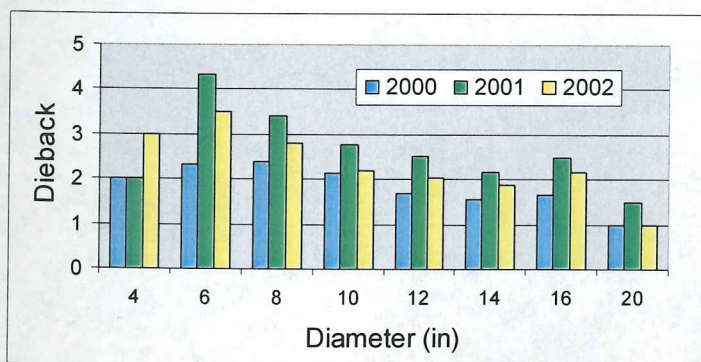
Overstory trees that survived (1 in 30 trees had died on the lowland plot and 2 of 30 had died on the hardwood site) in both the lowland and upland hardwoods sites continued to show bunched foliage with about 37% higher dieback and 30% lower foliage transparency in 2002 than 2001. Apparently new growth was concentrated on branches that hadn't been severely damaged by the storm. These trees likely will survive but growth rates will be significantly diminished. On the lowland site, silver maple dieback was so great as to warrant clearcutting in this case. Very few of the maples survived and clearcutting appears to have promoted better



Dieback generally increased and transparency decreased for all species and size classes, in both the upland and lowland hardwood sites in Manitowoc County.

sprouting than leaving dead and dying trees standing. Selective harvest of the older upland hardwood stand, however, seems to be working well as the remaining hardwoods will probably survive and growth of advanced regeneration of valuable species will produce a future stand.

In Douglas County, much of the damaged area had been harvested in the winter of 2001, including the sapling red pine and aspen. The sawtimber aspen stand, however, had been withdrawn from harvest in order to study the effects of the hail damage. These trees showed improvement with an average 20% decrease in crown dieback since 2001. As in previous years, dieback decreased with increasing stem diameter. The mortality rate was up from 1% in 2001 to 4% this year. Regeneration in the sawtimber stand was not doing as well as in the sapling aspen which had been clearcut. This is most likely due to increased shading from the overstory. As in the Waushara study, if the storm damage had been followed by severe drought or insect defoliation, harvesting would certainly have been warranted here as well.



Sawtimber aspen stand in Douglas County. Dieback generally improved for all size classes except saplings, due to increased shade from the overstory.

Annosum Root Rot Biocontrol Trial - Results after Two Years

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Introduction

Annosum root rot (*Heterobasidion annosum*) was first reported killing plantation pine in 1993 and has now been confirmed in 10 counties in Wisconsin. A biological control trial was initiated in 2001 at two locations in Sauk and Iowa counties (Sauk County Forest and the River Valley School Forest west of Arena- Iowa County). In 2002, additional



Fruiting bodies (conks) form at the base of infected trees and stumps

infection centers were found on the Sauk County Forest and treated as in 2001 (See Forest Health Conditions in Wisconsin: Annual Report 2001 for details of the treatment methods). The trial included a salvage harvest along with a stand thinning. A 30' barrier zone was created around the infection centers. Stumps in the harvested 30' barrier zone were treated with the fungus *Phlebiopsis gigantea*. The purpose of the trial was to see if *P. gigantea* could successfully

colonize the stumps and thus create a barrier to prevent spread of Annosum through grafted roots. Sporax (a product that creates an unfavorable environment for Annosum spore germination) was applied to all the other stumps created from the thinning to reduce potential new infections. A sanitation burn of the cut infected trees was also conducted to reduce potential for conk formation and additional air borne spore spread.



Top: Skidsteer used to pile brush for sanitation burn. Bottom: Sanitation burning of infected logs to reduce fruiting bodies

Results after two years

With collaborative assistance from the University of Minnesota, Plant Pathology Department, samples were taken from inoculated stumps at approximately 6, 12, and 50 weeks and cultured for recovery of *P. gigantea*. Although *P. gigantea* was recovered at all sites in SCF 2001 it was not recovered from all stumps. *P. gigantea* was not recovered at two of the fifteen sampling sites in the SCF 2002 treatment area. These two sites were in the driest portion of the forest with an open southerly exposure.

Percent colonization of *Phlebiopsis gigantea* in red pine stumps from the 2001 and 2002 biocontrol inoculations (% chips w/ *P. gigantea*).*

Sites	6-8 weeks	12-13 weeks	50 weeks
West Arena (RVSF)	10	43	77
Sauk County Forest (SCF 2001)	6	44	23
Sauk County Forest (SCF 2002)	16	49	n/a ^a

*Data summary from Crystal Marie Floyd, Biological Control of Root Rots in Forests Using Fungi, December 2002 M.S. Thesis, University of Minnesota, Plant Pathology Department.

n/a^a = data not taken

Additional Field Observations

In the fall of 2002 field observations were made at the 2001 Sauk County Forest (SCF 2001) treatment site. Each infection center was checked for presence of fruiting bodies (conks) in both the diseased area as well as the treated barrier. The stand was also surveyed for new infection centers. A total of 36 conks were detected on 13 stumps. Only one of the stumps with conks was in the treated barrier area. The rest were within the marked disease zone. A few stumps that were pulled up in the disease zone during the piling process, but did not make it to the burn pile, had resupinate (flat) Annosum conks present. Any of the stumps that were charred by the burn piles did not produce conks. Four new and three "break-over" infection centers were also detected in the stand.



Conks that form on the uprooted portions of stumps often have a resupinate (flat) growth pattern.

Discussion

The *P. gigantea* field trial inoculations had variable results with just under 50% recovery after 13 weeks. At 50 weeks the percent recovery at the West Arena site increased to 77% while the Sauk County Forest 2001 site decreased to 23%. This major difference in recovery is likely attributed to the size of the openings and the microclimate conditions created by the biocontrol project. The two West Arena sites had relatively small openings while the SCF 2001 had much larger openings due to the close spacing of the infection centers. These larger openings were much more arid and had more exposure to sunlight and winds. In the future, an addition of an anti-desiccant compound to the inoculum may increase colonization success of *P. gigantea*.

The field observations also indicate that the disease will continue to persist on old infected stumps at these sites. Based on the lack of conks observed on the charred stumps within the burn piles, complete coverage of burn material over the infected stumps may reduce conk formation. The rate of mortality of the four new and three "break over" infection centers indicate that these trees were likely infected at the time of treatment but symptoms had not developed to the point where they were visibly declining. This is likely the case with the one infected stump in the buffer area. The stump was on the inner ring of the barrier closest to the infection center and likely infected at time of treatment. Future monitoring of the treatment area will be needed to determine if the barrier is working.

Future Plans

In the fall of 2002 a new area of the Sauk County Forest was found heavily infected with Annosum root rot. A portion of this area is planned for a clearcut salvage operation in 2003 followed by a broadcast burn to see if burning will reduce disease on residual stumps. This area is then planned for a number of planting trials with various tree species yet to be determined.

Additional biocontrol treatments may occur in the current trial areas as before with the addition of an anti-desiccant compound to the inoculum. In addition, drip torching of old infected stumps may be tried to see if this charring would prevent conk formation.

Note

A special thanks goes to Crystal Floyd and the University of Minnesota, Plant Pathology Department for their assistance with this project.

For detailed methods on this project refer to: Crystal Marie Floyd, Biological Control of Root Rots in Forests Using Fungi, December 2002 M.S. Thesis, University of Minnesota, Plant Pathology Department and the 2001 Forest Health Conditions of Wisconsin.

Jane Cummings Carlson
Forest Pathologist
Wisconsin Dept. of Natural Resources

Introduction

The Wisconsin DNR has 3 forest tree nurseries that offer forest trees for sale to aid in regeneration of Wisconsin's forests. Over the past decade, a few reports of unusually high mortality of out-planted red pine have occurred. Investigation into these reports have yielded a number of factors that are affecting survival rates. One of these is the presence of *Sphaeropsis* collar rot, caused by the fungus *Sphaeropsis sapinea*. This fungus has long been known to cause a shoot blight but only recently has been observed infecting in the root collar area of seedlings while they are still in the nursery. This pathogen can infect seedlings in the nursery and remain latent, for years, without causing any symptoms in infected trees. Drought stress has been shown to increase the rate of growth of *Sphaeropsis* and hasten mortality. Infected seedlings may live for many years without showing any symptoms of infection or may die soon after out-planting, depending on site and weather factors.

In 2002, a joint effort to conduct a statewide survey of out-planted red pine was initiated by personnel in the nursery and forest health protection programs. A cooperative project between these programs and Dr. Glen Stanosz at the University of Wisconsin-Madison was also conducted to determine the incidence of *Sphaeropsis* collar rot in Wisconsin's forest tree nurseries. Results of Dr. Stanosz's work, entitled, "Frequency of seedling and seed contamination by *Sphaeropsis sapinea*" can be found in this annual report.

The objectives of the survey were to:

1. Determine incidence of fading and dead red pine in selected out-planting sites throughout Wisconsin.
2. Determine potential causes of mortality through field and laboratory observations.
3. Determine the incidence of *Sphaeropsis* Collar Rot on dying red pine.
4. Utilize survey data together with University of Wisconsin baseline data to develop a plan to improve survival of red pine out-plantings.

Methods



Figure 1. Pycnidia of *Sphaeropsis sapinea*.

Fifty-three sites in 25 counties were surveyed twice (sometime during mid-June through mid-July and again mid-July through fall). Sites were chosen to cover as much of the state as possible and survey seedlings originating from all 3 nurseries. Rows of trees were randomly surveyed and the number of healthy, fading and necrotic trees were counted until 250-1,000 trees had been observed. Additional data collected included date trees shipped from nursery, planting date, site prep and planting method. Field observations such as "planted too deep" or "wet, heavy soil" were also recorded. Up to 25 fading trees were collected and mailed to the DNR forest health lab for observations. In the lab, observations on general health were recorded and each seedlings was examined for the presence of pycnidia and spores of SCR (Figure 1).

Results

Mortality

A total of approximately 18,000 seedlings on 53 sites in 25 counties were surveyed twice during the 2002-growing season (see map on right). Ten sites had greater than 10% mortality after the first survey. Thirty sites had greater than 10% mortality after the second survey. (Figure 3). The lack of rainfall in June, July and August in southern Wisconsin and July and August in western Wisconsin was a likely contributor to the increase in mortality from June through August (Figure 4). In general, many of the seedlings that were fading or chlorotic during the first survey, were dead by the second survey.

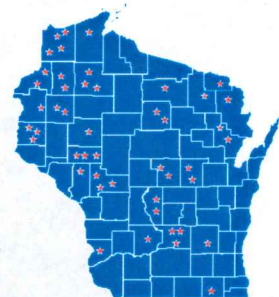


Figure 3. Percent Mortality by survey site

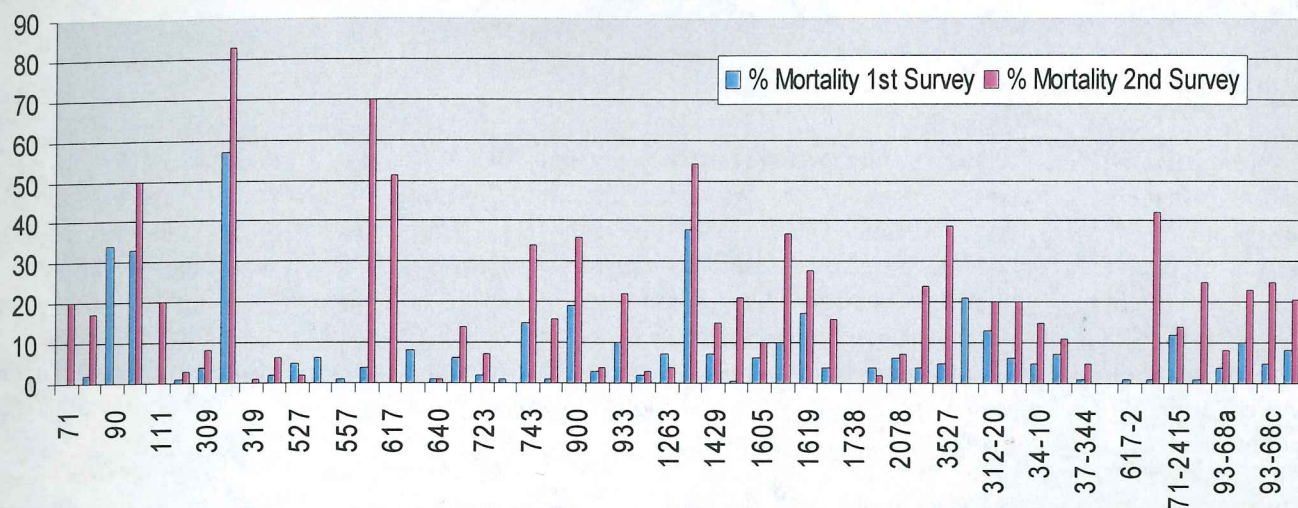


Figure 4. Maximum Temperature (F) by day from March 1 to August 31, 2000

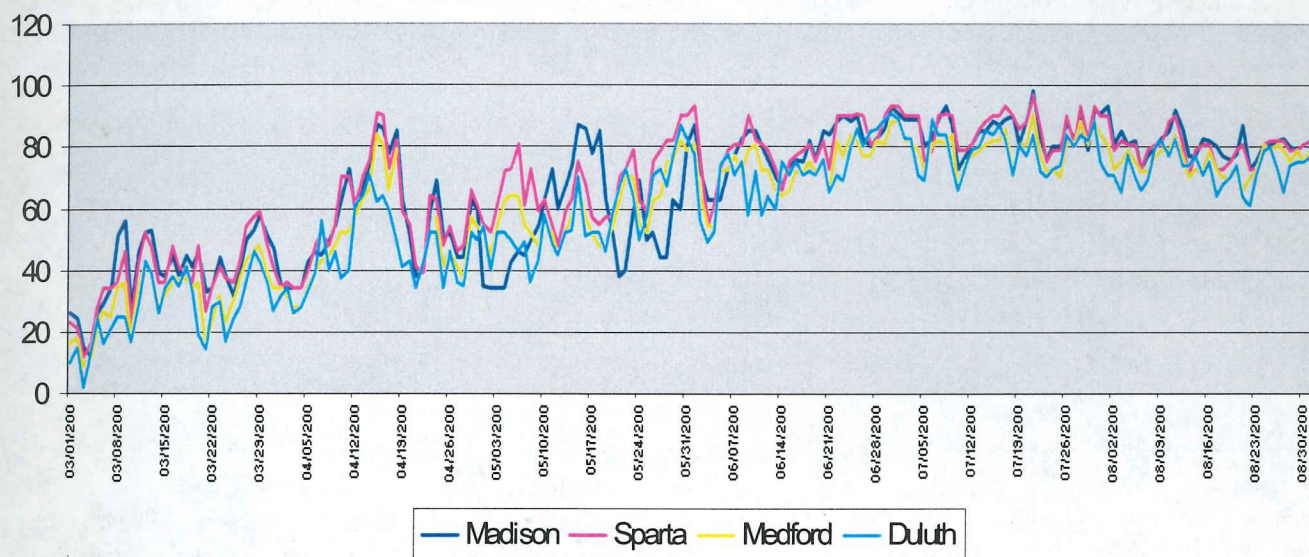
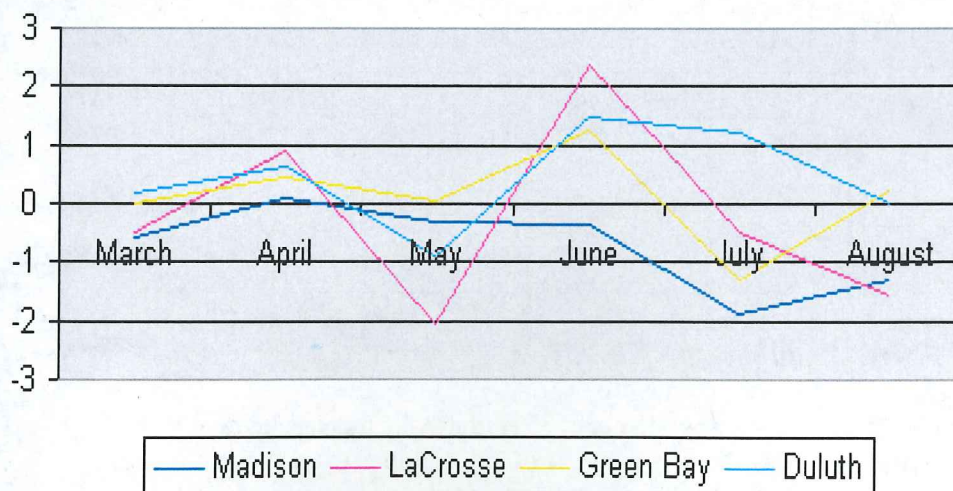


Figure 5. Departure from normal (in) for monthly precipitation.



Temperature during Lifting and Planting

The maximum temperature recorded during lifting and planting reached over 80°F twice (Figure 5) and may have affected the health status of the seedlings before or just as they were planted. If seedlings were shipped or stored in locations without refrigeration or shade, they could have easily overheated or desiccated. Several of the samples examined in the laboratory had signs of desiccation or overheating (Figures 6,7).

Figure 6. Seedling with desiccated roots, likely exposed to drying conditions during storage or planting.



Planting Methods

The average percent mortality was 19% for trees planted by machine and 24% for trees planted by hand with no statistical significance between planting methods. There was also no statistically significant difference between various site preparation methods. Average percent mortality was 22% for chemical site prep.; 17% for mechanical; 36% where both chemical and mechanical methods were used and 14% where no site prep. was conducted.

Figure 7. The cambium of this seedling has deteriorated; the seedling probably overheated some time between lifting and planting.



Field Observations

Field observations yielded several comments related to improper planting. The most common field observations of factors that may have contributed to mortality were 1) planted too deeply, 2) poor planting and 3) heavy, wet soil and 4) heavy weed competition (Figures 8,9).

Figure 8. Number of occurrences of various problems contributing to mortality.

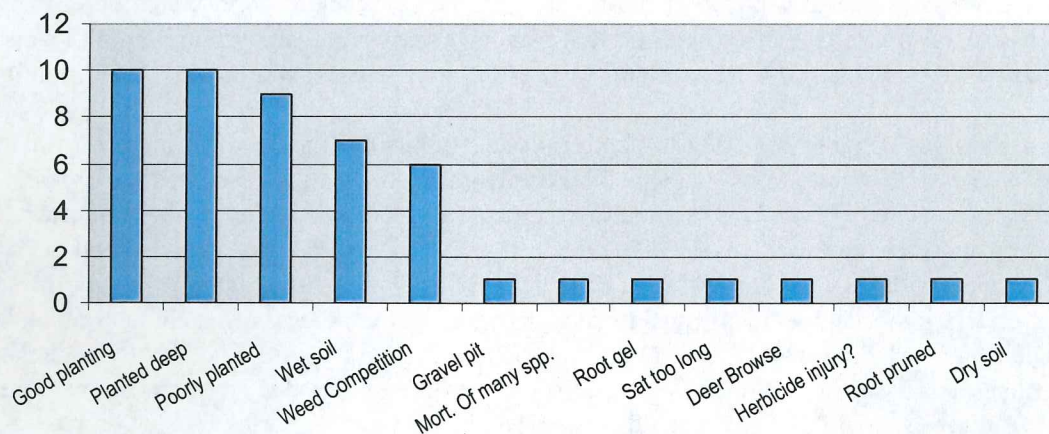
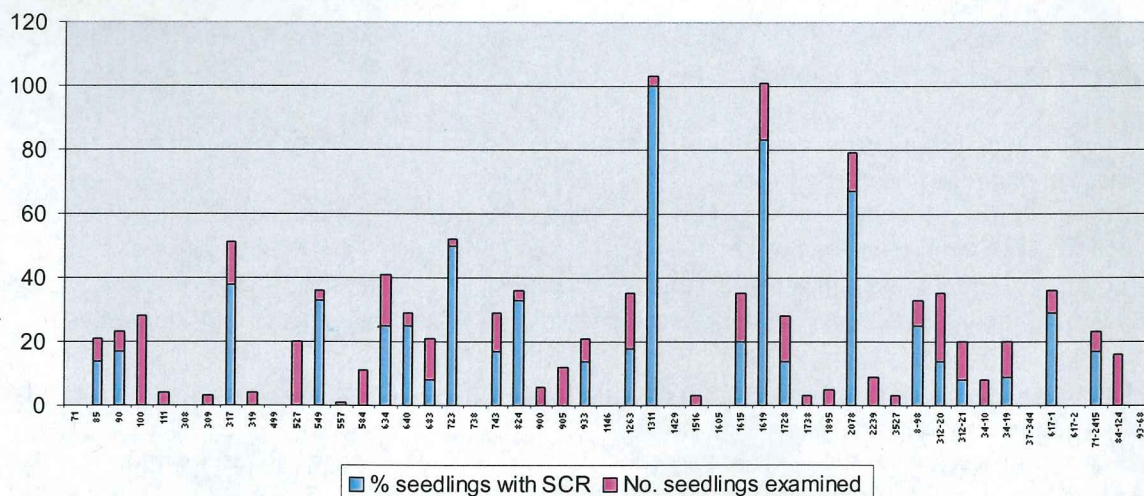


Figure 9. Number of seedlings examined and percent with Sphaeropsis collar rot by survey site.



Processing Time

An effort to determine the amount of time elapsed between lifting at the nurseries and planting in the field was unsuccessful as planting dates were either spread out over several days and sometimes weeks or the landowner did not keep track of the planting dates.

Laboratory Examination for *Sphaeropsis sapinea*

The number of chlorotic or fading seedlings collected from each site for examination varied between 1 and 20 but was generally under 10. Most sites did not have enough fading trees present during the first survey to provide a sufficient sample. This small number of seedlings examined per site is too low to make any statistically valid conclusions regarding the incidence of infection of fading seedlings. Figure 10 shows the number of seedlings examined from each site and the percent of seedlings examined that were positive for the presence of *Sphaeropsis* collar rot. *Sphaeropsis* collar rot was observed on 23 of the 39 sites sampled for this disease; this proves that *Sphaeropsis* collar rot continues to be present on dying out-planted red pine and continues to play a role in the health status of red pine seedlings.



Figure 10. Seedling planted too deep.

Discussion

Field and laboratory observations continue to support the hypothesis that a number of factors are affecting the survival rate of out-planted red pine seedlings. The high temperature (80°F) reached twice during the lifting and planting season provided conditions that could have stressed the trees if they had not been properly stored and handled during planting. The lack of moisture in June - August in southern Wisconsin and in July and August in western Wisconsin would have put the seedlings under a moisture deficit, creating an advantage for growth of *Sphaeropsis sapinea*. Infected seedlings that may have survived under normal rainfall levels, likely died due to the extremely dry soil conditions. Some sites were dry enough to cause mortality of healthy, uninfected seedlings.

The number of comments related to planting issues points out the need for more information and education for landowners on this topic. Observations of trees planted so deep only 1-3 inches were visible above ground or trees planted in extremely heavy grass competition indicate a lack of knowledge, interest or effort by some landowners in planting and maintaining their sites. No clear difference in survival was observed between various planting or site preparation methods. The survey group concluded that site preparation appropriate for the site and proper planting were clearly important yet must be considered as only part of the process of reaching acceptable levels of survival. *Sphaeropsis* collar rot was observed on chlorotic and fading trees from 23 of the 39 sites sampled. This fungus continues to play a role in influencing the survival rate of out-planted red pine and all management options available for this disease should be implemented in the DNR's forest tree nurseries.

Results of this survey prompted the formation of a long-term plan to address the multiple issues affecting seedling survival. The plan includes the following objectives:

1. Develop a long-term process for annually monitoring the status of selected newly planted red pine and following these plantations for several years.
2. Review existing literature and brochures covering the handling, storage and planting of seedlings. Revise and create new literature as needed.
3. Continue to implement *Sphaeropsis* collar rot management practices in all DNR forest tree nurseries. (Current practices include preventive fungicide sprays to prevent *Sphaeropsis* shoot blight and removal of infected wind-breaks).
4. Continue to support research efforts on development of new management practices for *Sphaeropsis* collar rot (as funds become available).

This plan was presented to the DNR Forestry Leadership Team in February. Plans are underway to form a committee to develop an implementation plan.

Frequency of seedling and seed contamination by *Sphaeropsis sapinea*

Progress Report, 18 February 2003 (funded July 2002- June 2003)

Prepared by Glen R. Stanosz^{1,2} and Denise R. Smith¹

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PROBLEM STATEMENT:

Pine shoot blight and canker caused by the fungus *Sphaeropsis sapinea* (syn. *Diplodia pinea*) is an important and worldwide disease of conifers, especially pines. Both seedlings and established trees are susceptible. Damage includes shoot blight, collar rot, cankers, root disease, and blue stain.

Some of the most frequent and severe damage caused by this pathogen in North America has occurred in Wisconsin. Incidence of shoot blight among red pine seedlings in nurseries has exceeded 30%. Partial removal of some diseased wind-break trees has reduced the initial inoculum. However, the disease remains chronic in seedling nurseries, necessitates repeated application of fungicides, and still reduces the efficiency of production.

Losses also may be locally severe in plantations. Apparently trees become more susceptible when subjected to physical damage (hail, pruning, etc.) or harsh site conditions. Collar rot, bole cankers, staining, root disease, and rapid crown wilt can then occur and lead to tree death. *S. sapinea* is suspected as the cause of extensive mortality in numerous young Wisconsin pine plantations since at least 1991.

Past studies of seedlings from the Wilson and Griffith nurseries has confirmed that virulent strains of *S. sapinea* can persist on or in asymptomatic, fungicide-treated red pine seedlings. An average of 27.5% of 100 asymptomatic seedlings from each of these two nurseries in 1994 yielded the pathogen. Similar seedlings obtained in 1996 and 1997 were used in greenhouse experiments to determine the effect of drought stress on the "latent" pathogen. Drought stress stimulated release of the pathogen from latency to result in collar rot and rapid mortality of seedlings. Approximately 70% of similar seedlings used in these drought studies yielded the pathogen. Thus, although treatment with fungicide (benomyl) succeeds in preventing disease within the nursery, this practice apparently does not prevent development of a relationship between the *S. sapinea* and red pines which can later result in disease including seedling death.

Knowledge of the frequency of asymptomatic persistence of *S. sapinea* on or in red pine nursery seedlings is limited to these previously described point-in-time "snapshots" from two nurseries. The current average frequency and range of variation within and among nurseries is unknown at this time and nursery at Hayward has never been sampled in this way. In addition, the potential that *S. sapinea* might also persist on or in red pine seed (a possible means of repeated entry into the nursery) has not been explored. Thus, the focus of this proposed project (which is limited by the amount of support available), is to obtain current information about the frequency of the pathogen on or in asymptomatic red pine nursery seedlings and seed.

OBJECTIVES: The objectives currently proposed for this project are to:

- 1) determine the frequency of asymptomatic colonization of red pine seedlings by *S. sapinea* in three DNR nurseries;
- 2) characterizing isolates as A types (presumably more aggressive) or B types;
- 3) determine the feasibility of detection of *S. sapinea* from red pine cones and seed.

PROGRESS TO DATE (18 FEBRUARY 2003) DIRECTED TOWARD OBJECTIVES 1 AND 2

Methods:

Objective 1) Methods for determining latent infection by fungal pathogens require use of rigorous surface disinfestation to eliminate propagules of the pathogen which might be casually associated with the plant surface. Our method is to immerse tissues for 30 seconds in 95% EtOH and then twice (for two minutes each time in 20% household bleach with Tween added as a wetting agent). The effectiveness of this procedure for use on red pine shoot tissues was verified previously. In addition

we have recently developed an amended medium that should improve our ability to detect the pathogen (i.e., provide a more accurate estimate of the frequency of contaminated seedlings).

Two sets of samples were obtained from each nursery. The first consisted of five groups of 20 seedlings (100 seedlings total) from a bed or beds in proximity to a potential source of inoculum (e.g., diseases windbreak trees) and in which symptoms of Sphaeropsis shoot blight were evident. This sample should reflect the upper end of the range of incidence of the pathogen. The second group of 100 seedlings will be taken from a bed or beds at some distance from any apparent source of inoculum and in which shoot blight symptoms are absent or scarce. This sample should reflect the lower end of the range of incidence of the pathogen. A segment of the first year's stem of each seedling was excised, surface disinfested, plated on the amended medium, incubated, and periodically inspected for presence of *S. sapinea*.

Objective 2) A subsample of isolates from these incubations will be obtained for type identification. Analysis of random amplified polymorphic DNA (RAPD) markers, previously applied for differentiation of A (aggressive) and B (less aggressive) types by our group, will be used to identify isolate types. The types of the isolates obtained will be compared with those previously collected from comparable host material in this region. The implication of detection of the aggressive A group, is that this group is responsible for subsequent development of collar rot and mortality of outplanted seedlings.

Results and Discussion:

Incidence of symptomatic seedlings varied both within and among nurseries (Table 1). Symptomatic seedlings were tended to be more frequent nearer the inoculum source and less frequent away from it. In proximity to windbreaks, symptomatic seedlings frequencies averaged >20% at all three nurseries, and was as high as 59% of one sample from Wilson. *S. sapinea* was detected on all or almost all examined symptomatic seedlings at these three nurseries (Table 1), indicating that it is the likely cause of the observed symptoms. The high incidence of Sphaeropsis shoot blight near windbreaks is consistent with previous reports (Palmer et al. 1988, Stanosz and Smith 1996). As suggested in the past, removal of these sources of primary inoculum is recommended. It is also noteworthy, that some symptomatic seedlings were present, though less frequently, in areas sampled at some distance from the windbreaks. The source of inoculum to initiate disease at these locations is uncertain. Once present however, *S. sapinea* can sporulate on these seedling to secondarily spread (and asymptotically persist as discussed below).

Detection of *S. sapinea* from asymptomatic seedlings also varied somewhat within nurseries (Table 1). The fungus was common from asymptomatic seedlings from the Wilson, Griffith, and Hayward nurseries, with incidence overall at least as common as in our previous study. Frequency of detection of *S. sapinea* from these asymptomatic seedlings at Wilson and Griffith was related to frequency of the presence of symptomatic seedlings in the same plots (i.e., high percentages of symptomatic seedlings were associated with high percentages of asymptomatic seedlings yielding *S. sapinea*). Thus, it appears that production of secondary inoculum on symptomatic seedlings might be a likely source of the pathogen persisting on asymptomatic seedlings and incidence of symptoms. Symptoms might be a good indicators of risk of dissemination of the pathogen with healthy-appearing stock from the same nursery beds.

All isolates obtained from asymptomatic seedlings from Wilson, Griffith, and Hayward, nurseries were characterized as belonging to the aggressive A group. This is consistent with our past findings and the relatively high incidences of shoot blight and mortality in some areas of these nurseries. Detection of some A group strains indicates the potential for additional damage in nursery production and after outplanting. Additional research including investigation of other potential inoculum sources in nurseries, practices to reduce shoot blight and asymptomatic persistence, and measures to prevent further establishment and spread of this aggressive group are justified.

ACKNOWLEDGEMENTS

Authors are grateful for financial support from the WI DNR, and for assistance from forest health and nursery personnel who are cooperating in this project.